APPENDIX A:

Network Park Ecological Profiles

ECOLOGICAL PROFILE
ANIAKCHAK NATIONAL MONUMENT AND PRESERVE

Physical Environment

Climate

Aniakchak's (ANIA) climate is cool, windy, and wet. Storms, brought by Pacific Ocean winds, frequently visit the area. The Aleutian Range acts as a weak physical barrier between two climatic zones: the Pacific Coast and Bristol Bay climatic regimes. The Pacific Coast has a maritime climate characterized by high precipitation and moderate temperatures. Bristol Bay has a more continental climate with lower precipitation, foggy summer days and wider temperature ranges.

Although no rain gauges or other weather measurements are located in the monument, annual precipitation along the coast probably averages 100 inches or more. Precipitation on the Aleutian peaks and in the caldera is doubtless higher yet. Cloudy skies predominate throughout the year.

The caldera has its own microclimate. Weather inside the caldera is affected by shifting air currents that carry weather from the two climate zones as well as by its own topography. Low cloud ceilings, rain and high winds are common, even when the weather is relatively calm outside the caldera.

Geology

Aniakchak National Monument and Preserve (Aniakchak) is located 400 miles southwest of King Salmon on the Alaska Peninsula. Although dominated by volcanism, scattered Pleistocene glacial deposits occur within the monument, and Jurassic and Cretaceous sedimentary formations of sandstone, shale, conglomerate and limestone are also present (USNPS 1985). In 2002, fossilized hadrosaur tracks were found.

Ancestral Aniakchak Volcano underwent a catastrophic explosive eruption about 3400 years BP, forming Aniakchak Caldera and blanketing much of the surrounding landscape with thick, fast-moving pyroclastic flows. The Caldera is 5.9 miles in diameter and encompasses an area of approximately 13.5 mi2. The rim averages 3281 feet in elevation with the highest point reaching 4400 feet. Aniakchak has erupted at least forty times in the past 10,000 years, with the most recent eruption occurring in 1931 (Neal et al 2001). Post formation volcanic activity within the caldera has resulted in the emplacement of numerous lava domes, maars, eruptions pits and lava flows (Miller 1990).The caldera remains thermally active as evidenced by the presence of several warm springs as well as areas with ground temperatures of 185o F at depths of 10 inches (Miller 1990).

Concurrent with the volcanic activity was a series of glacial advances that carved the landscape and deposited thick sequences of till and other glacial debris. During times of glacial maximums, ice sheets extended from the Aleutian Range well into coastal waters. Changes in sea level during this period produced near-shore marine deposits in the lowlands.

Hydrology

Aniakchak River Watershed

Surprise Lake, a large (660 acre) lake located along the northeast edge of the caldera floor, drains 80% of the caldera and is fed by 11 surface inlets and numerous warm and cold springs (Cameron and Larson 1992). "Turbid Lake" is an unnamed maar lake, of grey-green color, also located within the caldera. Its only inlet stream carries a high load of suspended particles. Outflow from the lake is underground for 100 feet before resurfacing as “Turbid Creek”, with suspended sediments little reduced. “Turbid Creek” joins the Aniakchak River near the crater walls.

The Aniakchak River heads eastward from Surprise Lake toward "the Gates" where it exits from the caldera. "The Gates" are vertical walls of uniform horizontal strata of banded grey sedimentary rock where the east rim of the crater is cut by a 2000 feet deep rift. In the upper 5 miles the river drops rather uniformly at a rate of about 100 feet per mile. The lower 17 miles flow through a broad valley up to 3 miles wide down to Aniakchak Bay. Despite its small volume and relatively short length, the Aniakchak River is the largest stream on the Alaska Peninsula draining into the Pacific Ocean.

Tributary streams of the Aniakchak River carry a high sediment load. As gradients lessen and velocities slow, sediment drops out, leading to highly meandered and braided streams.

Meshik River Watershed

Meshik Lake, at 66 acres, lies southeast of the caldera, and is fed by wetlands and small, steep drainages from Pinnacle Mountain. The Meshik River flows out of the southwest side of the park, including Meshik Lake, and discharges into Bristol Bay near Port Heiden. Many of its tributaries drain the south side of the caldera.

Cinder River Watershed

The upper reaches of the Cinder River drain the northeast portion of the park, and discharge into Bristol Bay.

Cameron and Larson (1992) conducted a two year study of physical, chemical and biological attributes of Surprise Lake. This study was the first comprehensive

baseline study of the Lake and inlet streams. From their field work, Cameron and Larson concluded,

> Many of the inlet streams and springs are influenced by hydrothermal fluids. In the vicinity of inlet streams and springs influenced by hydrothermal fluids, the near lake surface increased in temperature, conductivity, trace elements, and periphyton biomass, and decreased in pH and dissolved oxygen. For the whole lake, water quality and trace element concentrations were influenced to a lesser degree by the hydrothermal inputs….

Coastal/Marine

The Anaikchak coastline extends 80 miles from Cape Kunmik to Kujulik Bay on the peninsula's southern mountainous spine. The coast is rugged with precipitous cliffs, offshore reefs, and islands. Three sheer-faced peninsulas jut into the ocean creating three bays which are completely or partially within the preserve. Aniakchak and Amber Bays are large, exposed bays with wide cinder-covered beaches. Kejulik Bay is more protected, narrower, and has sandy, cinder beaches. Tidal forces are generally moderate. The Aniakchak River flows through a large lagoon into the ocean at Aniakchak Bay. Here, ancient beach lines parallel the modern beach for several hundred feet.

Biological Resources

Flora

Large expanses of cinder and tephra plains surround the crater itself. This area is largely barren, with scattered willow and forb patches around the edges and in lower drainages. Inside the caldera, wet herb and sedge meadows are concentrated near the outlet, and northwest end of Surprise Lake. Patches of willow, bluejoint grass and crowberry heath are found on the gentler, lower elevations of old lava flows, while more exposed areas remain unvegetated.

The Cinder river drainage has a few isolated cottonwood trees, relatively lush willow stands, and grass/forb meadows with patches of crowberry heath or wetlands. Alder patches grow in the valleys above the cinder plains. The upper Meshik River valley is dominated by wetlands. Willow and alder thickets occur near Meshik Lake, and along the Meshik River. Coastlands are likely dominated by bluejoint grass and forb meadows, alder patches and crowberry heath.

Fauna

Fishery Resources

Documented freshwater fish diversity in Aniakchak is low (Table 1), but a substantial intertidal zone in the Aniakchak River suggests that there is probably significant transient marine diversity.

Table 1. Fish Species – Aniakchak (NPSpecies 2003)

Scientific Name	Common Name	Status
Order: Cypriniformes – Family: Catostomidae		
Catostomus catostomus	longnose sucker	Probably Present
Order: Esociformes - Family: Umbridae		
Dallia pectoralis	Alaska blackfish	Probably Present
Order: Gasterosteiformes- Family: Gasterosteidae		
Gasterosteus aculeatus	Alaskan stickleback threespine stickleback	Present in Park
Pungitius pungitius	ninespine stickleback tenspined stickleback	Probably Present
Order: Osmeriformes- Family: Osmeridae		
Thaleichthys pacificus	eulachon	Probably Present
Order: Petromyzontiformes- Family: Petromyzontidae		
Lampetra japonica	Arctic lamprey	Probably Present
Lampetra tridentata	Pacific lamprey	Probably Present
Order: Pleuronectiformes- Family: Pleuronectidae		
Platichthys stellatus	starry flounder	Present in Park
Order: Salmoniformes- Family: Salmonidae		
Oncorhynchus gorbuscha	pink salmon	Present in Park
Oncorhynchus keta	chum salmon	Present in Park
Oncorhynchus kisutch	Coho salmon, silver salmon	Present in Park
Oncorhynchus mykiss	rainbow trout	Present in Park
Oncorhynchus nerka	sockeye salmon, red salmon	Present in Park
Oncorhynchus tshawytscha	chinook salmon, king salmon	Present in Park
Prosopium cylindraceum	round whitefish	Probably Present
Salvelinus malma	dolly varden	Present in Park
Thymallus arcticus	Arctic grayling	Probably Present
Order: Scorpaeniformes- Family: Cottidae		
Cottus aleuticus	coastrange sculpin	Unconfirmed

The Meshik and Cinder River systems have large runs of all five species of salmon. Smaller streams have runs of sockeye and chum. Surprise Lake provides spawning habitat and a nursery environment for anadromous sockeye salmon and Arctic Char (Mahoney and Sonnevil 1991), and chum salmon have begun to pioneer (Troy Hamon, Katmai National Park & Preserve, personal communications). The Aniakchak River supports all five species of salmon, with large runs of pinks and chums. Dolly Varden, arctic char, and other species occur in most streams.

In 1984, the U.S. Fish and Wildlife Service conducted a fishery resource survey of Meshik Lake and River in response to a proposed pipeline corridor across the lower reaches (outside the Monument boundary) of the Meshik River (Wagner and Lanigan 1988). US Fish and Wildlife Service personnel surveyed Surprise Lake for fishery resources during a 3 week trip to the caldera in 1987. A bathymetric map of the lake was prepared, and water quality of the lake and selected inlet streams was examined (Mahoney and Sonnevil 1991).Hamon (2001) has worked in Surprise Lake and the Aniakchak River since 1999, documenting spawning populations and habitats of sockeye salmon populations, and measuring morphological and habitat variables. In 2003, J. Miller (manuscript in prep) conducted a fisheries inventory of Aniakchak, with sampling

sites at Surprise Lake, the Aniakchak River and major tributaries, Pacific coast streams, and Meshik Lake.

Terrestrial Mammals

Thirty terrestrial mammal species are documented or are expected to occur within ANIA (Table 2). Some of the more commonly observed species include brown bear, moose, caribou, red fox, Arctic ground squirrel, and tundra vole. Species less frequently observed include wolf, river otter, wolverine, porcupine, and beaver. Information on the distribution, abundance, and breeding status of most terrestrial mammal species is limited. Existing survey and research data are described below. Much of the limited available information regarding terrestrial mammal species distribution and abundance has come from incidental records of mammal sightings noted by scientists and NPS staff (e.g., Del Vecchio 1992; Hamon 1999; Savage & Hasselback 1992; Stroud & Fuller 1984).

Table 2: Terrestrial Mammals – Aniakchak (NPSpecies 2003**)**

Scientific Name	Common Name
Order: Artiodactyla - Family: Cervidae	
Alces alces	Moose
Rangifer tarandus	Caribou
Order: Carnivora - Family: Canidae	
Alopex lagopus	Arctic fox
Canis latrans	Coyote
Canis lupus	Wolf
Vulpes vulpes	Red fox
Order: Carnivora - Family: Felidae	
Lynx canadensis	Lynx
Order: Carnivora - Family: Mustelidae	
Enhydra lutris	Sea otter
Gulo gulo	Wolverine
Lutra canadensis	River otter
Mustela erminea	Ermine
Mustela nivalis	Least weasel
Mustela vison	Mink
Order: Carnivora - Family: Otariidae	
Eumetopias	Stellar sea lion
Order: Carnivora – Family: Phocidae	
Phoca vitulina	Harbor seal
Order: Carnivora - Family: Ursidae	
Ursus arctos	Brown bear
Order: Insectivora - Family: Soricidae	
Sorex arcticus	Arctic shrew
Sorex cinereus	Masked shrew
Sorex monticolus	Montane shrew
Sorex tundrensis	Tundra shrew
Order: Lagomorpha - Family: Leporidae	
Lepus americanus	Snowshoe hare
Lepus othus	Arctic hare
Order: Rodentia - Family: Castoridae	
Castor canadensis	Beaver
Order: Rodentia - Family: Dipodidae	
Zapus hudsonius	Meadow jumping mouse
Order: Rodentia - Family: Erethizontidae	
Erethizon dorsatum	Porcupine
Order: Rodentia - Family: Muridae	
Clethrionomys rutilus	Northern red-backed vole
Dicrostonyx groenlandicus	Greenland collared lemming
Lemmus trimucronatus	Brown lemming
Order: Rodentia - Family: Muridae	
Microtus oeconomus	Tundra vole
Synaptomys borealis	Northern bog lemming
Order: Rodentia - Family: Sciuridae	
Marmota caligata	Hoary marmot
Spermophilus parryii	Arctic ground squirrel

ANILCA specifically provides for sport and subsistence trapping and hunting of wildlife in Aniakchak National Preserve, and for subsistence hunting and trapping in Aniakchak National Monument, consistent with applicable federal and state laws and regulations. The preserve encompasses about 80% of ANIA. To protect subsistence uses and manage for healthy wildlife populations, the NPS issues

concession contracts for sport hunting guide-outfitter services within Aniakchak National Preserve. The concessions contracts limit guided hunts to any species that may be legally taken under state non-subsistence regulations. Currently there are three guide areas in ANIA. ANIA receives copies of state reporting forms for animals harvested by contracted guides. The NPS also periodically receives updated copies of the state's harvest database and sealing records.

Brown bear.— During a late July float trip down the Aniakchak River from Surprise Lake to the coast, Del Vecchio (1992) reported brown bear, red fox, caribou, arctic ground squirrel, wolf, and coyote within the caldera; brown bear and caribou along the river corridor; and brown bear along the coast. Stroud and Fuller (1983) noted frequent sightings of brown bears along the coast during early June. Sowl (1988) found that bears were common within the caldera in early July (foraging on fresh grasses and forbs) and scarce from mid-July until late August when sockeye salmon were relatively abundant.

Observations suggest that bears may enter dens as late as December, and emerge in early May. Denning within ANIA is known to occur on the slopes of the caldera and areas on the east side of the Aleutian Range (USNPS 1986a). Bears descend to the coastal plains in spring, where they feed on caribou and moose calves and adults, marine mammal carcasses and other carrion, and green vegetation. Spring bear aggregations have been noted in Aniakchak Bay and Amber Bay. Bears appear to primarily distribute themselves relative to salmon availability from June through September. In August bears begin to supplement their diet with ripening berries. Stroud and Fuller (1983) reported timing of drainage use for areas that they patrolled. Sowl (1988b) noted that bears frequented Aniakchak Caldera once salmon began spawning there mid to late August. Salmon may be available in some drainages through late fall and early winter.

No brown bear research has been conducted in ANIA. However research was conducted from 1988 through 1996 at Black Lake, about 48 km southwest of ANIA, to assess brown bear population status (Sellers 1994; ADF&G 2003). Part of this research involved evaluating the effectiveness of aerial surveys of bears along salmon streams to detect population trends.

Available data suggest that the Alaska Peninsula brown bear population may have been overharvested in 1972-1973 (Sellers and McNay 1984). Surveys suggest that the bear population on the Alaska Peninsula has increased since the 1960s (Sellers and McNay 1984; ADF&G 2003). At least 21 bears were harvested within Aniakchak National Preserve during the 1999 regulatory year, and at least 17 were taken in the 1997 regulatory year (a regulatory year includes a fall and spring bear hunt) (ADF&G sealing records database).

Gray wolf.—Little is presently known about the numbers and range of wolves in ANIA. Sellers (1990a) reported that wolves occur at low to moderate densities

throughout the Alaska Peninsula. However, data on numbers and distribution were derived only from hide sealing records and anecdotal observations.

Moose.— Moose have been on the Alaska Peninsula since the early 1900s, but did not become abundant until the 1950s. Local residents first reported seeing moose in the Chignik area (just south of Aniakchak) in the mid 1940s (USNPS 1993a). The population peaked in the late 1960s, and the Alaska Peninsula became world renowned for trophy moose. Comparisons of trend surveys from 1969-1972 with those from 1982-1983 indicated moose numbers had declined by 60% or more (Sellers 1990b). The decline of moose numbers during the 1970s apparently resulted from low calf recruitment, after moose over-browsed their range. Predation on neonate calves by brown bears on the peninsula appeared to be a major factor preventing an increase in moose density even after range conditions had improved (Sellers 1990b).

In ANIA, moose primarily range over the lower willow- and alder-lined slopes and valleys, with concentrations along the upper Meshik and Cinder River valleys, and at the head of Amber Bay. The Alaska Department of Fish and Game (ADF&G) has established trend areas where aerial surveys of the moose population are carried out to monitor age and sex composition. Two of these trend areas encompass moderate to high quality moose wintering habitat in ANIA—one is centered around the Cinder River in the northern portion of ANIA, and the other includes coastal habitat in the southeast corner of ANIA. A new trend area, which has only been flown once to date, encompasses moose wintering habitat in the southwest portion of the preserve (KATM/ANIA unpubl. data 1999). ADF&G, NPS, and the U.S. Fish and Wildlife Service (USFWS), cooperatively work on surveying the trend areas. Ideally, each area is surveyed every one to three years. Poor snow and weather conditions have sometimes hampered efforts to survey the trend areas that include ANIA. Trend area surveys since the early 1980s indicate that the Peninsula population has remained relatively stable (R. A. Sellers, ADF&G, King Salmon, AK, unpubl. data).

Caribou.— The Northern Alaska Peninsula Caribou Herd (NAP) calves on the Bristol Bay coastal plain, and traditionally winters between the Egegik and Naknek Rivers (ADF&G 2003). Some NAP caribou may calve within ANIA, and in recent years as many as 500 NAP caribou have summered within the unit (R. Squibb, USFWS, King Salmon, AK, personal communication).

From 1981-1993, the NAP remained relatively stable with between 15,000-20,00 animals. Since that time, herd size has declined. In 2001 and 2002 post-calving counts remained at about 6,400 animals (ADF&G 2003). Cooperative studies by ADF&G and the USFWS and other indicators suggest that deteriorating range condition were the primary cause of the NAP decline (ADF&G 2003).

Furbearers.—To date, no ANIA furbearers have been formally surveyed.

Small Mammals.—Four short-term small mammal surveys have been conducted in ANIA: one at Aniakchak Bay (T.W. Trapp, ANIA, unpubl. data, 1992), and two in the caldera (Jarell 1987; T.W. Trapp, ANIA, unpubl. data, 1992). These surveys documented the presence of specific small mammal species. Jarell's (1987) trapping efforts suggested that masked shrew, dusky shrew, meadow vole, and arctic ground squirrels were the most common and widespread species in the caldera.

Birds

About 129 bird species are documented or expected to occur within ANIA, including 47 landbird species, 47 inland waterbird species, and 35 seabird species (Table 3). Studies and surveys of bird species in ANIA are few—surveys for nesting Bald Eagles have been conducted (see below), and an effort was made to survey bird species in Aniakchak Caldera in 1987 (Meyer 1987). Therefore, information on bird species largely consists of anecdotal sighting records noted by NPS ranger and resource management staff.

Some of the more regularly noted landbird and inland waterbird species in patrol reports (locations and timing of patrols and surveys varied—some included Anaikchak Caldera) include Red-throated Loon, Greater Scaup, Harlequin Duck, Barrow's Goldeneye, Common Merganser, Bald Eagle, Rough Legged Hawk, Sandhill Crane (seasonal), Semipalmated Plover, Lesser Yellowlegs, Wandering Tattler, Whimbrel, Western Sandpiper, Least Sandpiper, Rock Sandpiper, Common Snipe, Red-necked Phalarope, Belted Kingfisher, Tree Swallow, Bank Swallow, Common Raven, Hermit Thrush, American Dipper, American Pipit, Savannah Sparrow, Golden-crowned Sparrow, Lapland Longspur, Snow Bunting, Rosy Finch, and Common Redpoll (Stroud and Fuller 1983; Manski et al. 1987, Meyer 1987; Sowl 1988a; Starr and Starr 1988a; Savage 1993b). Peregrine Falcon and Gyrfalcon sightings are infrequent, but have been noted in a number of NPS patrol and survey reports. Some of the more common seabird species in anecdotal records include cormorants, Black Oystercatcher, Mew Gull, Glaucous-winged Gull, Black-legged Kittiwake, Arctic Tern, Common Murre, Pigeon Guillemot, Marbled Murrelet, Kittlitz's Murrelet, Ancient Murrelet, and Horned Puffin (Stroud and Fuller 1983; Manski et al. 1987; Meyer 1987; Sowl 1988b; Starr and Starr 1988a; Savage 1993b)

The Boreal Partners in Flight Working Group identified six landbird species as "priority species" for western/southwestern Alaska—Gyrfalcon, Gray-cheeked Thrush, Varied Thrush, Golden-crowned Sparrow, McKay's Bunting, and Hoary Redpoll (Andres 1999). Gyrfalcons are uncommon in anecdotal sighting records, but similar to Peregrine Falcon, they are noted on occasion in NPS patrol and survey reports. Meyer (1987), Sowl (1988b), and Savage (1993b) described Golden-crowned Sparrow as a common species in Aniakchak Caldera, and Sowl (1988b) described evidence of nesting there. Golden-crowned Sparrows were

Table 3. Bird Species – Aniakchak (NPSpecies 2003)

Scientific Name	Common Name
Order: Anseriformes - Family: Anatidae	
Anas acuta	Northern pintail
Anas Americana	American wigeon
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Aythya marila	Greater scaup
Branta bernicla	Brant
Branta Canadensis	Canada goose
Bucephala albeola	Bufflehead
Bucephala clangula	Common goldeneye
Bucephala islandica	Barrow's goldeneye
Chen canagica	Emperor goose
Clangula hyemalis	Long-tailed duck
Cygnus columbianus	Tundra swan
Histrionicus histrionicus	Harlequin duck
Melanitta fusca	White-winged scoter
Melanitta nigra	Black scoter
Melanitta perspicillata	Surf scoter
Mergus merganser	Common merganser
Mergus serrator	Red-breasted merganser
Polysticta stelleri	Steller's eider
Somateria mollissima	Common Eider
Somateria spectabilis	King eider
Order: Ciconiiformes - Family: Accipitridae	
Aquila chrysaetos	Golden eagle
Buteo lagopus	Rough-legged hawk
Circus cyaneus	Northern harrier
Haliaeetus leucocephalus	Bald eagle
Order: Ciconiiformes - Family: Charadriidae	
Charadrius semipalmatus	Semipalmated plover
Haematopus bachmani	Back oystercatcher
Pluvialis dominica	American golden plover
Pluvialis fulva	Pacific golden-plover
Pluvialis squatarola	Black-bellied plover
Order: Ciconiiformes - Family: Falconidae	
Falco peregrinus	Peregrine falcon
Falco rusticolus	Gyrfalcon
Order: Ciconiiformes - Family: Gaviidae	
Gavia immer	Common loon
Gavia stellata	Red-throated loon
Order: Ciconiiformes - Family: Laridae	
Aethia cristatella	Crested auklet
Aethia pusilla	Least auklet
Brachyramphus brevirostris	Kittlitz's murrelet
Brachyramphus marmoratus	Marbled murrelet
Order: Ciconiiformes - Family: Laridae	
Cepphus columba	Pigeon guillemot
Cerorhinca monocerata	Rhinoceros auklet
Cyclorrhynchus psittacula	Parakeet auklet
Fratercula cirrhata	Tufted puffin
Fratercula corniculata	Horned puffin
Larus canus	Mew gull
Larus glaucescens	Glaucous-winged gull
Larus philadelphia	Bonaparte's gull
Ptychoramphus aleuticus	Cassin's auklet
Rissa tridactyla	Black-legged kittiwake
Stercorarius longicaudus	Long-tailed jaeger
Stercorarius parasiticus	Parasitic jaeger
Stercorarius pomarinus	Pomarine jaeger
Sterna paradisaea	Arctic tern
Synthliboramphus antiquus	Ancient murrelet
Uria aalge	Common murre
Uria lomvia	Thick-billed murre
Order: Ciconiiformes - Family: Phalacrocoracidae	
Phalacrocorax auritus	Double-crested cormorant
Phalacrocorax pelagicus	Pelagic cormorant
Phalacrocorax urile	Red-faced cormorant
Order: Ciconiiformes - Family: Podicipedidae	
Podiceps grisegena	Red-necked grebe
Order: Ciconiiformes - Family: Procellariidae	
Fulmarus glacialis	Northern fulmar
Oceanodroma furcata	Fork-tailed storm petrel
Oceanodroma leucorhoa	Leach's storm-petrel
Puffinus griseus	Sooty shearwater
Puffinus tenuirostris	Short-tailed shearwater
Order: Ciconiiformes - Family: Scolopacidae	
Actitis macularia	Spotted sandpiper
Aphriza virgata	Surfbird
Arenaria interpres	Ruddy turnstone
Arenaria melanocephala	Black turnstone
Calidris alba	Sanderling
Calidris alpina	Dunlin
Calidris mauri	Western sandpiper
Calidris minutilla	Least sandpiper
Calidris ptilocnemis	Rock sandpiper
Calidris pusilla	Semipalmated sandpiper
Gallinago gallinago	Common snipe

Heteroscelus incanus	Wandering tattler
Limnodromus griseus	Short-billed dowitcher
Limosa fedoa	Marbled godwit
Numenius phaeopus	Whimbrel
Phalaropus lobatus	Red-necked phalarope
Order: Ciconiiformes - Family: Scolopacidae	
Phalaropus tricolor	Wilson's phalarope
Tringa flavipes	Lesser yellowlegs
Tringa melanoleuca	Greater yellow-legs
Tringa solitaria	Solitary sandpiper
Order: Coraciiformes - Family: Cerylidae	
Ceryle alcyon	Belted kingfisher
Order: Galliformes - Family: Phasianidae	
Lagopus lagopus	Willow ptarmigan
Lagopus mutus	Rock ptarmigan
Order: Gruiformes - Family: Gruidae	
Grus Canadensis	Sandhill crane
Order: Passeriformes - Family: Alaudidae	
Alauda arvensis	Eurasian skylark
Order: Passeriformes - Family: Certhiidae	
Troglodytes troglodytes	Winter wren
Order: Passeriformes - Family: Cinclidae	
Cinclus mexicanus	American dipper
Order: Passeriformes - Family: Corvidae	
Corvus caurinus	Northwestern crow
Corvus corax	Common raven
Pica pica	Black-billed magpie
Order: Passeriformes - Family: Fringillidae	
Calcarius lapponicus	Lapland longspur
Carduelis flammea	Common redpoll
Carduelis hornemanni	Hoary redpoll
Dendroica petechia	Yellow warbler

Junco hyemalis	Dark-eyed junco
Leucosticte arctoa	Rosy finch
Leucosticte tephrocotis	Grey-crowned rosy finch
Melospiza melodia	Song sparrow
Passerculus sandwichensis	Savannah sparrow
Passerella iliaca	Fox sparrow
Plectrophenax nivalis	Snow bunting
Spizella arborea	American tree sparrow
Vermivora celata	Orange-crowned warbler
Wilsonia pusilla	Wilson's warbler
Zonotrichia atricapilla	Golden-crowned sparrow
Zonotrichia leucophrys	White-crowned sparrow
Order: Passeriformes - Family: Hirundinidae	
Riparia riparia	Bank swallow
Tachycineta bicolor	Tree swallow
Order: Passeriformes - Family: Laniidae	
Lanius excubitor	Northern shrike
Order: Passeriformes - Family: Muscicapidae	
Catharus guttatus	Hermit thrush
Catharus minimus	Gray-cheeked thrush
Turdus migratorius	American robin
Order: Passeriformes - Family: Paridae	
Parus atricapillus	Black-capped chickadee
Order: Passeriformes - Family: Passeridae	
Anthus rubescens	American pipit
Anthus spinoletta	Water pipit
Motacilla flava	Yellow wagtail
Order: Passeriformes - Family: Regulidae	
Regulus calendula	Ruby-crowned kinglet
Order: Strigiformes - Family: Strigidae	
Asio flammeus	Short-eared owl

also described as abundant on the ANIA coast by Manski et al. (1987).

Bald Eagle.—Bald Eagles can be commonly found nesting and feeding along rivers and the coastline of ANIA. They have also been observed within Aniakchak Caldera and on the cliffs north of Meshik Lake (USNPS 1986a). Stroud and Fuller (1984) observed eleven active nests along the northeastern shore of Amber Bay and along the northern shore of Cape Kumlik. An aerial raptor survey was conducted along the ANIA coast in 1988 (Starr and Starr 1988b). Aerial surveys of the ANIA coast for Bald Eagle nests and productivity were conducted in 1989 and 1990 in an effort to monitor impacts of the Exxon Valdez oil spill (Payer 1989; Dewhurst 1990). An adult Bald Eagle survey of the entire Alaska Peninsula was conducted by USFWS during late April 2000. The stratified random plot quadrat sampling included 2 sample plots that encompassed the Amber Bay coastline and vicinity (Savage and Hodges 2000).

Terrestrial Threatened and Endangered Species

Currently no federally listed species are known to occur in terrestrial areas of ANIA. The USFWS formerly listed some wildlife species as category 2 candidate species, which indicated that further research was needed to assess biological vulnerability, taxonomy and/or threats. This designation was discontinued in 1996, and those species are now referred to by the USFWS as "species of concern." Harlequin Duck is a species of concern that occurs in freshwater areas of ANIA. Lynx, which is also a former category 2 species, is at the southern boundary of its range in ANIA, and sightings are rare.

The Boreal Partners in Flight Working Group identified six landbird species as "priority species" for western/southwestern Alaska—Gyrfalcon, Gray-cheeked Thrush, Varied Thrush, Golden-crowned Sparrow, McKay's Bunting, and Hoary Redpoll (Andres 1999). Gyrfalcons are uncommon in anecdotal sighting records, but similar to Peregrine Falcon, they are noted on occasion in NPS patrol and survey reports. Meyer (1987), Sowl (1988) and Savage (1993) described Golden-crowned Sparrow as a common species in Aniakchak Caldera, and Sowl (1988) described evidence of nesting there. Golden-crowned Sparrows were also described as abundant on the ANIA coast by Manski et al. (1987).

A State of Alaska Species of Special Concern (2002) is any species or subspecies of fish or wildlife or population native to Alaska that has entered a long-term decline in abundance or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance. Steller's Eider, Golden Eagle, Peregrine Falcon, and Gray-cheeked Thrush are species known to occur in Aniakchak that are listed as Species of Special Concern.

Natural Resources Management Issues

- **Commercial Fishing**. Harvesting of salmon, especially in the commercial fishery, may be one of the greatest threats to the Surprise Lake/Aniakchak River system. Overharvest may adversely effect salmon endemic to this system and alter the volume and distribution of nutrients in the aquatic-terrestrial food web.

- **Petroleum development, storage, and transportation-** The marine coastline of Aniakchak is at constant risk from environmental threats associated with petroleum development, storage, and/or transportation. Aniakchak beaches were oiled by the 1989 EVOS and residual pockets of unweathered oil persist (Irvine In press).

- **Subsistence and Recreational Activities**. Non-consumptive recreational visitation is limited and typically focuses on the same small areas in the most accessible locations. More than 90% of ANIA's visitation is by guided hunters and anglers (USNPS 1986a). ORV use, associated with subsistence activities, occurs in wetlands and along stream channels on the coastal drainages. Erosion and compaction associated with these recreational and subsistence activities may have localized adverse effects on stream morphology and spawning habitat.

- **Global Warming**. ANIA's environment is thought to be very susceptible to climate change. Changes in the thermal regime can extend ice-free seasons, usually leading to increases in the ratio of evaporation + evapotranspiration to precipitation, and result in less water in the landscape (Schindler 1997).

- **Air quality**. Little air quality data has been collected in the park, but it is assumed that ANIA's air is pristine due to its remote location. However, the global dispersion and deposition of pollutants has subjected many remote areas to pollutants.

ECOLOGICAL PROFILE
ALAGNAK WILD RIVER
and
KATMAI NATIONAL PARK AND PRESERVE

Katmai National Park and Preserve (Katmai) lies astride the Aleutian Range on the Alaska Peninsula. This dynamic land has been repeatedly covered by massive glaciations, buried in volcanic ash, and exposed to powerful storms from the North Pacific. Its lakes and streams nurture, and are nurtured by some of the largest salmon runs in the world. Migrating waterfowl nest in the marshlands, brown bears fatten for hibernation on the spawning salmon, seals and whales patrol the coastal lagoons and offshore waters, while vegetation slowly recolonizes a wind blasted, ash-covered land.

Physical Environment

Climate

The climate of the Alaska Peninsula and Katmai NP&P is heavily influenced by storms originating in the North Pacific and moving along a storm track that parallels the Aleutian chain. Storm frequency for the Katmai NP&P area is greatest during the late summer and early fall from August through October (Klein 1957). Additionally, local geographic conditions produce a variety of microclimates.

Katmai's eastern and southern coasts bordering Shelikof Strait have a Maritime climate characterized by small temperature variations, high humidity, heavy precipitation, high occurrence of clouds and fog, temperatures generally above freezing, cool summers, and warm winters (Selkregg 1976). Temperatures on Kodiak Island, the most representative of any weather station of Katmai's Maritime climate, range between 29.7^{o} F in January and 55.0^{o} F in August (Figure 1, Western Region Climate Center Data, 2002). Precipitation for the Kodiak Island station ranges between 4.12 inches in July and 8.36 inches in October with an annual precipitation of 75.35 inches. (Figure 2, Western Region Climate Center, 2002).

The North Pacific high pressure system dominates the area during the summer, bringing south to southwest winds, while in winter, the weather is controlled by the Aleutian low atmospheric pressure system. Winds associated with this system are generally north to northwesterly. Summer winds tend to be slightly higher than in winter and are more consistent in direction. The highest winter monthly average wind speed in Kodiak is12.7 mph found in both December and January, while the lowest monthly average is 7.7 mph in July (NOAA 1998). High winds are common along the Shelikof Strait due to the funneling of air between Kodiak Island and the Aleutian Range.

The Aleutian Range also forms a cloud barrier, creating orographic rainfall with annual precipitation along the Shelikof coast that ranges between 20 and 70 inches (Jones and

Fahl 1994). Precipitation on the high eastern flank of the Aleutian Range may exceed 200 inches per year.

West of the coastal range, Katmai can be classified as Transitional with climate conditions intermediate between Maritime and Continental. Mean annual temperature at King Salmon ranges between 15.4^{o} F in January to 55.7^{o} F in July. Southeasterly and easterly winter winds predominate in the King Salmon area from October through March (Waythomas 1994). These winter winds are associated with high pressure over northern Alaska and low pressure over the southern Bering Sea and Gulf of Alaska. Summer winds, present between June and September, are generally from the south or southeasterly direction. During the late winter and early spring, February to May, winds are from the north or northeast. Strongest winds for King Salmon come from the east. Average wind speeds for King Salmon display little monthly variability with a high of 11.5 mph in March and a low of 9.9 mph in July (USNOAA 1998).

Geology

Katmai rests above a convergent plate margin, part of the circum-pacific *Ring of Fire*, and one of the most active volcanic belts in the world. The 1912 eruption of Novarupta, and subsequent caldera forming collapse of Mt Katmai are the most notable volcanic events occurring in Katmai NP&P in historic times. Ash from Novarupta covered the adjacent valley to great depth, creating numerous fuamaroles and thus the name, the Valley of Ten Thousand Smokes. Mt. Trident erupted in 1952, and minor ash eruptions and outbursts have also occurred on Mount Mageik, Mount Martin, Novarupta and Mt. Katmai since the 1912 eruption (Wilcox 1959:419).

Hydrology

Katmai stretches over five river basins. The Naknek, Kvichak, and Egegik River Basins are on the western side of the Aleutian Range and drain into Bristol Bay. The North and South Coastal Basins are on the eastern side of the Aleutian Range and drain into Cook Inlet and the Shelikof Strait, respectively. Within these five watersheds are a great diversity of rivers and lakes.

Katmai NP&P contains the largest freshwater lake in the National Park system (Naknek Lake) and some of the largest lakes in Alaska (Table 4, Table 5). These lakes make up approximately 8% of the park's surface area. Glaciers make up 216,000 acres (6%) of Katmai NP&P (USNPS 1994). The hydrologic cycle in the park is influenced in part by extensive glaciers and snowfields that supply vast quantities of silty meltwater to the drainage basin headwaters during the summer months.

Katmai has an extensive and diverse array of stream types, from steep, glacial fed rivers to small, intermittent streams varying in gradient, rate of flow, and geology. Streams draining the eastern side of the Aleutian Range are typically short, high gradient on bedrock. In contrast, on the western side of the range rivers flowing toward Bristol Bay consist of large, low gradient rivers and small, low gradient stream

complexes. Generally anadromous fish populations are much higher in the interior, low gradient streams.

The Naknek River Basin

The Naknek River Basin is the largest drainage basin in Katmai. Seventy-three percent (2,660 mi^2) of the 3,640 mi^2 drainage is located within Katmai's boundary (USNPS 1997:26). From it's outlet in Naknek Lake to Kvichak Bay, the Naknek River flows approximately 35 miles and drains seven major lakes: Naknek, Brooks, Coville, Grosvenor, Idavain, Murray, and Hammersly (Table 4), all found within the park. The Naknek River is a major producer of sockeye salmon with total runs averaging 5.0 million from 1983-1992 (Crawford and Cross 1995). Fish are harvested by commercial fishers in a commercial gill net fishery in Bristol Bay, by sport and subsistence fishers in the Naknek River, and by sport fishers in Katmai.

Table 4. Major Lakes Contained within the Naknek River Drainage of Katmai (USNPS 1994; Burgner et al 1969:409).

Lake	Area (mi^2)	Maximum Depth (ft)	Altitude (ft)	Lake	Area (mi^2)	Maximum Depth (ft)	Altitude (ft)
Brooks	29	846	62	Idavain	4.2	226	732
Coville	13	568	108	Jo-Jo	2.6	115	~100
Grosvenor	29	1145	101	Murray	1.0	140	~1650
Hammersly	3.4	170	1599	Naknek	228	1850	33

Coville Lake has the shallowest basin receiving its water from snowmelt and runoff via the 80 km American Creek. It serves as a settling basin, clarifying the water for downstream Grosvenor Lake, which drains into the Savonoski River. The Savonoski River receives additional drainage from glacier fields, then flows into the Iliuk Arm of Naknek Lake. Iliuk Arm receives ash flows from the Valley of Ten Thousand Smokes via the Ukak River. Heavy loads of rock flour and ash from these sources significantly affect water quality and transparency at the east end of Naknek lake. Westward, the clear Brooks Lake flows into the Naknek via the Brooks River, mixing with the turbid waters of Iliuk Arm. Brooks Lake receives snowmelt and runoff from low mountains and lowland wet tundra. Snowmelt and runoff from wet tundra also supply water to the North Arm of Naknek Lake. The west end of Naknek lake is relatively shallow and separated from the North Arm by a moraine.

In the Valley of Ten Thousand Smokes, weathering of the 1912 ash and input from thermal and cold springs result in very different physical and chemical properties of streams. Fish do not spawn in these streams, and the limited vegetation plays little role in the cycling of nutrients. Knife Creek and River Lethe, the two major streams draining the deposit, are enriched in dissolved constituents (silicon dioxide, calcium, sodium, potassium, magnesium, lithium, chlorine, fluorine, sulphate) compared to streams and springs that have not had contact with the ash flow (Keith et al. 1990:1691).

The Kvichak River Basin

The Kvichak River Basin is 60 miles wide and extends 170 miles in its greatest length. (USDI 1952). This basin contains two large lakes located outside of Katmai's boundary: Lake Clark (143 mi^2) (although Lake Clark is within a separate NPS unit), and Lake Iliamna (1,226 mi^2), the largest lake in Alaska.

The Alagnak River is a "Wild River" component of the National Wild and Scenic Rivers system and a separate unit of the NPS administered by Katmai NP&P staff. It is a tributary of the Kvichak River Basin, and one of the major tributaries to the Bristol Bay. The Alagnak River originates at Kukaklek Lake (Table 5) at an altitude of 800 feet and flows 74 miles westward to the Kvichak River. The first 20 miles of the river are steepest, falling roughly 17.8 feet/mile. After the confluence of the Nonvianuk and Alagnak Rivers the remaining 54 miles have a gentler gradient, averaging 7.8 feet/mile (Clay et al. 1983:3). The Nonvianuk River drains Nonvianuk Lake, and measures 11.5 miles in length. The average gradient is 15.2 feet/mile (Clay et al. 1983:3). .Additional major streams located in the Alagnak River drainage within Katmai NP&P are the Kulik and Battle rivers and Nanuktuk, Moraine, and Funnel creeks.

Table 5. Major Lakes Contained within the Alagnak River Drainage of Katmai National Park and Preserve (USNPS 1994 and Burgner et al 1969:409).

Lake Name	Area (mi^2)	Altitude (feet)	Lake Name	Area (mi^2)	Altitude (feet)
Battle	5.0	833	Mirror	0.6	~1300
Iron Springs	0.3	~1650	Nonvianuk	51.5	626
Kukaklek	67.5	802	Pirate	0.8	1148
Kulik	10.7	659	Spectacle	0.8	~950

The Egegik River Basin

The southwest corner of the park is contained within the Egegik River Basin. This Basin extends from within 5 miles of the Shelikof Strait coast to Bristol Bay, and is approximately 40 miles in length (USDI 1952). Contact, Angle and Takayoto creeks, the largest streams within the park for this Basin, flow west into the King Salmon River. The headwaters of the Kejulik River lie in the park's southeastern end. This river drains into Becharof Lake in the Becharof National Wildlife Refuge. There are no large lakes within the park boundaries in the Egegik River Basin.

The North Coastal Basin

Along Katmai's coast, the Kamishak River, Little Kamishak River, Strike Creek, and Douglas River flow into Kamishak Bay located in Cook Inlet. This coastal region is strongly influenced by vast quantities of silty glacial runoff during the summer months, and turbidity patterns can vary locally. For example, northern Kamishak Bay is much clearer than southern Kamishak Bay (Suchanek 1994).

The South Coastal Basin

The South Coastal Basin drains into Shelikof Strait. Numerous named (e.g., Katmai River, Alagogshak Creek) and unnamed streams flow down the characteristically short,

steep drainages into the Shelikof Strait (USNPS 1994). A number of the coastal streams flow from massive glaciers of the Aleutian Range and are colored with glacial flour. Other streams, such as the Katmai River, are heavily laden with volcanic ash.

Dakavak Lake is the largest coastal lake, approximately 2.8 miles long and 0.6 miles wide (1.7 mi2) with a depth greater than 69 feet. Heard et al. (1969) believes that most lakes along KATM's coast are glacial in origin and are relatively deep for their size.

Gunther (1992) examined basic water quality parameters of 12 lakes in the Naknek and Alagnak drainages in 1984 -1986. During the summers from 1990-1992, LaPerriere (1996, 1997) assessed conditions in 11 large lakes and some of the important inlet, outlet, and connecting streams along the Naknek and Alagnak drainages within Katmai NP&P. Data needs and long-term monitoring recommendations for Katmai NP&P were presented in LaPerriere (1996).

In 1996 and 1997, the U.S. Fish and Wildlife Service sampled six sites (three per year) for hydrocarbons in Katmai NP&P waters that receive heavy public use (Kulik Lodge, Grosvenor Lake Lodge, Alagnak Wild River, Naknek Lake, Brooks Lake and Lake Camp). Elevated hydrocarbon concentrations and visual observations were reported at several sites during this project. (Johnson and Berg 1999).

Coastal/Marine

The Katmai National Park and Preserve coastline extends from the mouth of the Kamishak River in Kamishak Bay to Cape Kubugakli in Shelikof Strait. The dominant feature is the Shelikof Strait coastline, a complex of narrow fjords, island and seastack bays, sandy beaches, and rocky headlands. The Strait is a southwest continuation of Cook Inlet extending approximately 170 miles to a juncture with the waters of the North Pacific Ocean. This complex ecosystem includes river drainages, salt marshes, beaches, intertidal zones, estuaries, coastal uplands, and islands.

In contrast, the Kamishak Bay shoreline in southern Cook Inlet has a more monotonous appearance. At low tide, vast mudflats extend up to 6 miles offshore interspersed with scattered rock outcrops and headlands. Higher on the beach, large slabs of sandstone are scattered around like huge flagstones. Nordyke Island is the largest of these. Although outside the boundary of the Park and Preserve, Augustine Island dominates the seascape in Kamishak Bay.

The entire Katmai coastline has been shaped by glaciation, with long, narrow fjords and U-shaped valleys. Typically rivers enter at the heads of the fjords and are characterized by shorter, wider estuarine embayments. Exposed bedrock and shallow soils prevail on headlands and islands. Ice scour and moraine deposits in Shelikof Strait provide evidence that ice completely filled the Strait and spilled out onto the Continental Shelf during past glacial advances. The seafloor in Shelikof Strait is broad and generally flat with closed basins. Along the south side of the Alaska Peninsula, Shelikof Strait has relatively steep slopes descending over 190

meters in the south; areas of deepest water in Shelikof Strait occur along the southeastern side adjacent to Kodiak Island where they reach to depths of 240 meters.

Biological Resources

Flora

Bristol Bay lowlands, moraines and lakes: Wetlands support communities dominated by sedges, mosses and dwarf shrubs. Wetland and pond complexes provide nesting and rearing habitat for many species of waterfowl and shorebirds. Slight ridges are better drained and support “subforests” of white spruce and Kenai birch, with alder thickets and patches of *Calmagrostis* grasslands. The southernmost extent of white spruce on the Alaska Peninsula is just south of King Salmon. The moraines support spruce and birch/balsam poplar forests with low and dwarf shrub communities in the understory and openings. The unit around Lake Colville supports wetlands and fairly dense spruce forests on the higher ground and side slopes. Lacustrine deposits and old lake terraces west of Brooks and Naknek Lakes are vegetated with sedge/low shrub tundra and open alder stands.

Mountains: The Kejulik and Cape Douglas Mountains are permanently glaciated, with valley glaciers nearly reaching the Shelikof coast. Below, barren, exposed ridgetops and outcrops, and patches of alpine tundra and low shrubs, find footholds in sheltered niches and shallower patches of ash from the 1912 Katmai eruption. Lower slopes support dense alder stands, with a few Sitka spruce on the coastal headlands. Several valleys around Novarupta and Katmai, and slopes on the eastern side of the range, are still covered with deep ash deposits that remain unvegetated. The Walatka mountains and Kamishak highlands support dwarf shrub and alpine tundras at higher elevations, with dense alder on lower slopes and cottonwood stands along the streams in the lowest valleys. Beaver help shape floodplains of streams from sea level to the upper limits of alpine low willow. Portions of the large west-flowing river valleys are forested with white spruce, with balsam poplar along the floodplains.

Coastlands: are generally unstable, but adapted to repeated disturbances, and support early successional communities of sedges, aquatic forbs and grasses. Alder and elderberry patches provide nitrogen for the soils, and sheltered sites support stands of Sitka spruce.

Wetlands: Katmai NP&P contains extensive wetlands that include marine, estuarine, riverine, palustrine, and lacustrine environments (estimates exceed 1 million acres). The park’s wetlands represent transitional environments, located between uplands and deepwater areas. Flora within these wetland systems exhibits extreme spatial variability, triggered by very slight changes in elevation. Temporal variability is also great because the surface water depth is highly influenced by changes in precipitation, evaporation and/or infiltration.

There are a number of tundra ponds, beaver ponds, and small tundra lakes along the park's western and northern boundary. These bodies of water are shallow, frequently contain submerged and emergent aquatic vegetation, and occasionally have no surface connections with major stream systems (Heard et al. 1969). The Savonoski River/Bay of Islands area and the Margot Creek drainage, located in the park's interior, also contain extensive marshes and ponds.

Fauna

Fishery Resources

During 1972-91, the annual run of sockeye salmon bound for the Naknek and Kvichak drainages averaged 15.3 million fish, 53% of the total Bristol Bay run – one of the largest in the world. From 1985-91, the sockeye escapement into the Naknek drainage averaged 1.8 million, and 5.4 million into the Kvichak drainage (USNPS 1994). Harvests of wild salmon have declined in the past 5 years for a variety of reasons.

The most widespread and abundant fish species in Katmai NP&P include Pacific salmon, trout, char, whitefish, and grayling (Table 6). Species of anadromous Pacific salmon in Katmai NP&P include sockeye (red), chinook (king), coho (silver), chum (dog), and pink (humpy). Rainbow trout is the only species of trout known to occur in the park. Species of char include lake trout, arctic char, and dolly varden. Whitefish are well represented, with round, pygmy, broad, and humpback whitefish, as well as least cisco. Arctic grayling are also present in the park.

Rainbow trout is another important species of fish in Katmai NP&P. While rainbows are not harvested commercially and are minimally harvested by subsistence fishermen, they support a world class sport fishery and attract anglers from all over the world especially to the Alagnak River. All access to the Alagnak River is by air, and this area is considered to be one of the most popular fly-in destinations in Southwest Alaska (USGS 1999). Little is known, however, about the ecology and life history of rainbow trout populations, along with most other species of fish in the Alagnak drainage.

Lake trout are the largest resident freshwater fish, with some of the largest probably exceeding 50 pounds (ADF&G 1994). Arctic char and Dolly Varden char also occur in Katmai National Park and Preserve. Arctic char are thought to be freshwater residents, although there is some evidence that there may be sea-going populations. Dolly Varden may occur as either freshwater or anadromous forms.

Round and pygmy whitefish are very common throughout the Naknek drainage in the main stem, lakes, and streams. The greatest density of round whitefish occurs in Coville Lake.

Table 6. Fish Species - Katmai (NPSpecies 2003)

Scientific Name	Common Name	Status
Order: Clupeiformes - Family: Clupeidae		
Clupea harengus pallasii	Pacific herring	Present in Park
Order: Cypriniformes – Family: Catostomidae		
Catostomus catostomus	longnose sucker	Present in Park
Order: Esociformes - Family: Esocidae		
Esox lucius	northern pike	Present in Park
Order: Esociformes - Family: Umbridae		
Dallia pectoralis	Alaska blackfish	Unconfirmed
Order: Gadiformes- Family: Gadidae		
Gadus macrocephalus	Pacific cod	Probably Present
Order: Gadiformes- Family: Lotidae		
Lota lota	burbot	Present in Park
Order: Gasterosteiformes- Family: Gasterosteidae		
Gasterosteus aculeatus	Alaskan stickleback, threespine stickleback	Present in Park
Pungitius pungitius	ninespine stickleback, tenspined stickleback	Present in Park
Order: Osmeriformes- Family: Osmeridae		
Hypomesus olidus	pond smelt	Present in Park
Hypomesus pretiosus	surf smelt	Present in Park
Osmerus mordax	rainbow smelt	
Thaleichthys pacificus	eulachon	Present in Park
Order: Perciformes – Family: Trichodontidae		
Trichodon trichodon	Pacific sandfish	Present in Park
Order: Petromyzontiformes- Family: Petromyzontidae		
Lampetra japonica	Arctic lamprey	Present in Park
Order: Pleuronectiformes- Family: Pleuronectidae		
Platichthys stellatus	starry flounder	Present in Park
Order: Salmoniformes- Family: Salmonidae		
Coregonus clupeaformis	lake whitefish	Present in Park
Coregonus pidschian	humpback whitefish	Unconfirmed
Coregonus sardinella	least cisco	Present in Park
Oncorhynchus gorbuscha	pink salmon	Present in Park
Oncorhynchus keta	chum salmon	Present in Park
Oncorhynchus kisutch	Coho salmon	Present in Park
Oncorhynchus mykiss	rainbow trout	Present in Park
Oncorhynchus nerka	red salmon, sockeye salmon, kokanee	Present in Park
Oncorhynchus tshawytscha	chinook salmon	Present in Park
Prosopium coulteri	pygmy whitefish	Present in Park
Prosopium cylindraceum	round whitefish	Present in Park
Salvelinus alpinus	Arctic char	Present in Park
Salvelinus malma	dolly varden	Present in Park
Salvelinus namaycush	lake trout	Present in Park
Thymallus arcticus	Arctic grayling	Present in Park
Order: Scorpaeniformes- Family: Agonidae		
Asterotheca alascana	gray starsnout	Probably Present
Pallasina barbata	tubenose poacher	Present in Park
Order: Scorpaeniformes- Family: Cottidae		
Cottus aleuticus	coastrange sculpin	Present in Park
Cottus cognatus	slimy sculpin	Present in Park
Icelinus borealis	northern sculpin	Probably Present
Leptocottus armatus	Pacific staghorn sculpin	Present in Park
Order: Scorpaeniformes- Family: Cyclopteridae		
Liparis gibbus	polka-dot snailfish, variegated snailfish	Probably Present

Terrestrial Mammals

Thirty-five terrestrial mammal species are documented or are expected to occur within KATM (Table 7). Commonly observed species include brown bear, moose, caribou, red

fox, ermine, mink, porcupine, beaver, Alaskan hare, snowshoe hare, red squirrel, Arctic ground squirrel, northern red-backed vole, and little brown bat. Species less frequently observed include wolf, coyote, lynx, river otter, wolverine, and marten. KATM maintains records of anecdotal observations reported by park staff and visitors, and some anecdotal observations have also been documented in patrol reports and unpublished resource management project reports. Although a few species, particularly brown bear, have been studied, information on the distribution and abundance of most mammal species is limited to these records.

Table 7. Mammal Species – Katmai (NPSpecies 2003, Goatcher, personal communication)

Scientific Name	Common Name
Order: Artiodactyla - Family: Cervidae	
Alces alces	Moose
Rangifer tarandus	Caribou
Order: Carnivora - Family: Canidae	
Canis latrans	Coyote
Canis lupus	Wolf
Vulpes vulpes	Red fox
Order: Carnivora - Family: Felidae	
Lynx canadensis	Lynx
Order: Carnivora - Family: Mustelidae	
Enhydra lutris	Sea otter
Gulo gulo	Wolverine
Lutra canadensis	River otter
Martes americana	Marten
Mustela erminea	Ermine
Mustela nivalis	Least weasel
Mustela vison	Mink
Order: Carnivora - Family: Otariidae	
Eumetopias jubatus	Stellar sea lion
Order: Carnivora – Family: Phocidae	
Phoca vitulina	Harbor seal
Order: Carnivora - Family: Ursidae	
Ursus arctos	Brown bear
Order: Cetacea – Family: Monodontidae	
Delphinapterus leucas	**beluga whale**
Order: Cetacea – Family: Balaenopteridae	
Balaenoptera physalus	**fin whale**
Megaptera novaeangliae	**humpback whale**
Order: Chiroptera - Family: Vespertilionidae	
Myotis lucifugus	Little brown bat
Order: Insectivora - Family: Soricidae	
Sorex arcticus	arctic shrew
Sorex cinereus	Masked shrew
Sorex hoyi	Pygmy shrew
Sorex monticolus	Montane shrew
Sorex tundrensis	Tundra shrew
Order: Lagomorpha - Family: Leporidae	
Lepus americanus	Snowshoe hare
Lepus othus	Arctic hare
Order: Rodentia - Family: Castoridae	
Castor canadensis	Beaver
Order: Rodentia - Family: Dipodidae	
Zapus hudsonius	Meadow jumping mouse
Order: Rodentia - Family: Erethizontidae	
Erethizon dorsatum	Porcupine
Order: Rodentia - Family: Muridae	
Clethrionomys rutilus	Redback vole
Dicrostonyx groenlandicus	Greenland collared lemming
Lemmus trimucronatus	Brown lemming
Microtus oeconomus	Tundra vole
Microtus pennsylvanicus	Meadow vole
Ondatra zibethicus	Muskrat
Synaptomys borealis	Northern bog lemming
Order: Rodentia - Family: Sciuridae	
Marmota caligata	Hoary marmot
Spermophilus	Ground squirrel
Spermophilus parryii	Arctic ground squirrel
Tamiasciurus hudsonicus	Red squirrel

ANILCA specifically provides for sport and subsistence trapping and hunting of wildlife in Katmai National Preserve, consistent with applicable federal and state law and regulations. The preserve encompasses approximately 413,000 acres of the northwest corner of KATM (about 11% of KATM).

Brown bear.—Most bears emerge from their dens by mid-May. During the spring bears feed on sedges, grasses, forbs, carrion, and moose calves in some areas. On the coast, bears congregate to feed on salt marshes located in many of the large bays. Some bears also feed on marine invertebrates available in adjacent intertidal habitat. As the season progresses, spawning salmon become a primary food source for bears, and the distribution of bears largely reflects the distribution of salmon. Bears congregate at numerous salmon spawning streams throughout the Park and Preserve. Salmon are available in a few streams as early as late June, and in some streams as late as October. During August, berries also become an important food item throughout the Park and Preserve. Information on bears numbers, composition, and timing of use has been obtained for selected salmon streams and coastal sites via aerial stream surveys and observational monitoring and research projects (Troyer 1974a, 1976a, 1977a, 1977b, 1978a, 1980a, Jope and Casebeer1983; Jope 1984a, 1985a, 1986a; KATM unpubl. data 1988, 1992, 1993). However, differences in survey methods and observer and pilot experience among years have made multi-year comparisons of the data problematic.

To assess the effects of the Exxon Valdez oil spill on brown bears, a study was conducted on the KATM coast from 1989-92 to monitor the survival and productivity of radio-collared females, measure levels of hydrocarbons in fecal samples, and estimate population density (Sellers and Miller 1999; Sellers et al. 1999). Capture mark-resight techniques (CMR) were used to estimate the brown bear density for a 901-km² KATM coastal study area (Sellers et al. 1999). For bears of all ages, the CMR density estimate was 0.5 bears/km2 , the highest density ever reported in North America (based on 1990 data; Miller et al. 1997).

Data on survival rates, sources of mortality, and bear productivity were also obtained from the radio-collared bears, and from collaring and tracking the activities of additional bears collared in 1993 (Sellers et al. 1999). The density estimates and subjective impressions of the relative density of bears in different parts of the Park were used to extrapolate to a bear population estimate of 1,500 to 2,000 bears for the entire KATM (Sellers et al. 1999). This total includes an estimated 131-184 bears in Katmai National Preserve (a density of 0.1 - 0.2 bears/km2) (Sellers et al. 1999).

Observational research has been conducted into the effects of human activity on bear use at several locations in KATM (Beattie 1983; Braaten and Gilbert 1987; Warner 1987; Braaten 1988; Olson et al. 1990; Olson and Squibb 1990, 1991; Olson 1993; Olson and Gilbert 1994; Olson et al. 1997a, 1997b; French et al. 2001; Smith et al. 2001). In addition, the effects of a new viewing structure and boardwalk have been investigated at Brooks River (J. Peirce and DeBruyn 1999; T. DeBruyn, NPS Alaska Support Office, manuscript in prep.), use of soft-shelled and Pacific razor clams by coastal bears has been investigated (T.S. Smith, USGS Alaska Science Center, manuscript in review), bear use of Brooks River has been monitored annually since 1999 using observational sampling methods (KATM unpubl. data 1999-2001) bear use of the Moraine-Funnel Creek confluence has

been documented (K. Proffitt, KATM, manuscript in prep.; T.L. Olson, KATM, manuscript in prep.), human-bear interactions and bear activity at Big River on the KATM coast has been investigated (T. Smith and S. Partridge, USGS Alaska Science Center, unpubl. data), and bear responses to novel sight sounds and odors has been researched (T. Smith, USGS Alaska Science Center, unpubl. data). Most of these research and monitoring projects have produced annual estimates of the number and composition of bears that used the study area based on individual bear identification records. At Brooks River, these data have been obtained using observational sampling methods in most years since 1985. Although not based on structured sampling, bear numbers and composition at Brooks River have also been periodically estimated since 1976 by resource management staff (Troyer 1980b; J. Peirce and DeBruyn 1999; KATM unpubl. data).

Since 1990, bear-human interactions and bear-management related events have been documented using bear management report forms (BMRF) (Holmes 1991, 1992, 1993, 1994; Boyd 1996, 1997; Carden and McFarland 1998, K. N. Peirce and Debruyn 1999; Proffitt 2002; Olson et al. 2002; USNPS 2001; KATM unpubl. data). Because reports are recorded opportunistically, for the most part the records cannot be used to compare frequency of incidents among sites, years, etc. However, use of BMRFs has resulted in more consistent documentation of events, and the records can be used to derive minimum estimates of occurrence

In the past 10 years, brown bear harvest per regulatory year (includes a fall and a spring bear hunt) in Katmai National Preserve has ranged from 10 to 19 bears, an average of 7 bears per year (ADF&G bear fur sealing database).

Gray wolf.—Little is presently known about the numbers and range of wolves in KATM. Sellers (1990a) reported that wolves occur at low to moderate densities throughout the Alaska Peninsula. However, data on numbers and distribution were derived only from hide sealing records and anecdotal observations. Park sighting records suggest the existence of at least four or five small wolf packs within and adjacent to KATM.

Moose.— Moose have been on the Alaska Peninsula since the early 1900s, but did not become abundant until the 1950s. The population peaked in the late 1960s, and the Alaska Peninsula became world renowned for trophy moose. Comparisons of trend surveys from 1969-1972 with those from 1982-1983 indicated moose numbers had declined by 60% or more (Sellers 1990b). The decline of moose numbers during the 1970s apparently resulted from low calf recruitment, after moose over-browsed their range. Predation on neonate calves by brown bears on the peninsula appeared to be a major factor preventing an increase in moose density even after range conditions had improved (Sellers 1990b).

The Alaska Department of Fish and Game (ADF&G) has established trend areas where aerial surveys of the moose population are carried out to monitor age and sex composition. These include areas along the Park and Preserve boundary (the oldest area dates back to 1969). ADF&G, NPS, and the U.S. Fish and Wildlife Service

(USFWS), cooperatively work on surveying the trend areas. Typically, each area is surveyed every one to three years. Moose trend area surveys since the early 1980s indicate that the Peninsula population has remained relatively stable (R. A. Sellers, ADF&G, unpubl. data).

Other moose surveys that have been conducted in Katmai National Park include a moose parturition survey of the central western part of the park in 1985 (Sellers 1985) and a winter moose survey of most drainage's in the park in 1975 (Troyer 1975a).

The most recent moose density estimate reported for Game Management Unit 9 (0.3 moose/ km2; Sellers 1990b) dates back nearly 20 years, and was for a 1,314-mi2 area of primary moose habitat in central GMU 9(E). The best moose habitat, which is similar in quality to moose habitat in the park boundary trend area, had an average of 0.9 moose/ km2.

Caribou.— The Northern Alaska Peninsula Caribou Herd (NAP) calves on the Bristol Bay coastal plain (southwest of KATM), and traditionally winters between the Egegik and Naknek Rivers. Prior to 1986, NAP caribou were generally found only in areas along the southwest boundary of KATM, including the Angle/Takayofo drainage and the headwaters of the Brooks drainage. Other than the occasional bands found in the King Salmon Creek drainage, it was unusual for caribou of the NAP to travel north of the Naknek River, or for caribou of the Mulchatna herd to travel south of the Kvichak River (which is northwest of the KATM boundary). However, since that time Mulchatna caribou have been traveling further south during the winter and have intermingled with the NAP in the area between the Naknek River and Lake Iliamna. By 1991, caribou wintering areas included the western areas of the park east of Dumpling Mountain (near Brooks River), as well as parts of Katmai National Preserve. A portion of the NAP now crosses, or attempts to cross, the Naknek River between King Salmon and the Naknek Lake outlet during their northward fall migration. The narrow band of NPS land between the Naknek lake outlet and Lake Camp provides the only protected passage for the herd to pass (although hunting continues on privately owned inholdings).

From 1981-1993, the NAP remained relatively stable with between 15,000-20,000 animals. Since that time, herd size has declined. In 2001 and 2002 post-calving counts remained at about 6,400 animals (ADF&G 2003). Cooperative studies by ADF&G and the USFWS suggest that deteriorating range condition were the primary cause of the NAP decline (ADF&G 2003).

Furbearers.—To date, no KATM furbearers have been formally surveyed.

Small Mammals.— Aside from collection of a few specimens during biological reconnaissance work in Katmai National Monument (Schiller and Rausch 1956), little is known about small mammals in KATM. A limited trapping study was conducted in the summer of 1973 at three sites in the monument (Dennis 1973). Systematic hare counts were recorded along the VTTS road during the summer of 1992-1992 and 1994 (Holmes 1992a, 1994a).

Marine Mammals

Sea otters occur along most of the Katmai coastline and are most numerous near Douglas Reef, Kiukpalik Island, Nukshak Island and Shakun Reef (Herendeen 1989). Estimates of sea otter abundance have ranged from 400-600 in 1989 (Herendeen 1989) to 130 in 1993 (Potts et al. 1993). Harbor seals occur in all the bays and haulout on nearshore reefs and islands. Steller sea lions, a federally-listed threatened species, use most of the Katmai coastline. Although the park's coastal waters are relatively shallow, beluga whales, fin whales, and humpback whales regularly occur offshore and in bays (Goatcher, pers comm).

Birds

About 180 bird species are documented or expected to occur within KATM, including 81 landbird species, 64 inland waterbird species, and 35 seabird species (Table 8).

Most landbird surveys in KATM have consisted of species lists and simple counts (e.g., Cahalane 1944; Trapp 1981; Boyd 1997; Savage 1996). Breeding bird surveys (BBS) were conducted along the Valley of Ten Thousand Smokes Road (VTTS) from 1992-96 and in 2000. (S. Savage, KATM, unpubl. data). The Boreal Partners in Flight Working Group identified six landbird species as "priority species" for western/southwestern Alaska—Gyrfalcon, Gray-cheeked thrush, Varied Thrush, Golden-crowned Sparrow, McKay's Bunting, and Hoary Redpoll (Andres 1999). Gyrfalcons are uncommon in anecdotal sighting records; an active Gyrfalcon nest and a second pair of Gyrfalcons were documented in 1993 in KATM during an aerial Peregrine Falcon survey (White et al. 1993). Gray-cheeked Thrush, Varied Thrush, and Golden-crowned Sparrow were documented in all years of the VTTS BBS (S. Savage, KATM unpubl. data).

Most waterbird surveys in KATM have occurred as part of broader-scale survey efforts conducted by the USFWS. Spring waterfowl surveys of the Naknek River have been conducted by the USFWS in most years since 1983 (Burke 1992; Cook 1992; Mehall 1993; Moore 1996; Ruhl and Moore 1996; Alaska Peninsula/Becharof National Wildlife Refuge, unpubl. data). A ground-based multi-point component was added to these surveys in 1991, which includes a survey point at Lake Camp within KATM. In addition, a waterfowl fall staging survey was conducted along the Naknek River using the same ground-based observation points (Scharf 1993).

Major breeding populations of ducks and other waterbirds have been surveyed by aircraft in Alaska every spring since 1957 as part of the North American Waterfowl Breeding Pair Survey. This survey includes transects in the Bristol Bay area (Conant et al. 2000). Between 1993-1994, this survey was expanded to include more intensive transect survey efforts (Platte and Butler 1995). Waterbird distribution maps, which include some western portions of KATM, were produced based on these surveys (Platte and Butler 1995).

Table 8. Bird Species – Katmai (NPSpecies 2003)

Scientific Name	Common Name
Order: Anseriformes - Family: Anatidae	
Anas acuta	Northern pintail
Anas americana	American wigeon
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas penelope	Eurasian wigeon
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anser albifrons	Greater white-fronted goose
Aythya americana	Redhead
Aythya collaris	Ring-necked duck
Aythya fuligula	Tufted duck
Aythya marila	Greater scaup
Aythya valisineria	Canvasback
Branta bernicla	Brant
Branta canadensis	Canada goose
Branta canadensis leucopareia	Aleutian canada goose
Branta nigricans	Brant
Bucephala	Goldeneyes
Bucephala albeola	Bufflehead
Bucephala clangula	Common goldeneye
Bucephala islandica	Barrow's goldeneye
Chen caerulescens	Snow goose
Clangula hyemalis	Long-tailed duck
Cygnus columbianus	Tundra swan
Histrionicus histrionicus	Harlequin duck
Lophodytes cucullatus	Hooded merganser
Melanitta fusca	White-winged scoter
Melanitta nigra	Black scoter
Melanitta perspicillata	Surf scoter
Mergus merganser	Common merganser
Mergus serrator	Red-breasted merganser
Oxyura jamaicensis	Ruddy duck
Polysticta stelleri	Steller's eider
Somateria mollissima	Common eider
Somateria spectabilis	King eider
Order: Ciconiiformes - Family: Accipitridae	
Accipiter gentilis	Northern goshawk
Accipiter striatus	Sharp-shinned hawk
Aquila chrysaetos	Golden eagle
Buteo lagopus	Rough-legged hawk
Circus cyaneus	Northern harrier
Circus cyaneus hudsonius	Marsh hawk
Haliaeetus leucocephalus	Bald eagle
Pandion haliaetus	Osprey
Order: Ciconiiformes - Family: Charadriidae	
Charadrius semipalmatus	Semipalmated plover
Haematopus bachmani	Black oystercatcher
Pluvialis dominica	American golden-plover
Pluvialis squatarola	Black-bellied plover
Order: Ciconiiformes - Family: Falconidae	
Falco columbarius	Merlin
Falco peregrinus	Peregrine falcon
Falco rusticolus	Gyrfalcon
Falco sparverius	American kestrel
Order: Ciconiiformes - Family: Gaviidae	
Gavia adamsii	Yellow-billed loon
Gavia immer	Common loon
Gavia stellata	Red-throated loon
Order: Ciconiiformes - Family: Laridae	
Aethia cristatella	Crested auklet
Brachyramphus brevirostris	Kittlitz's murrelet
Brachyramphus marmoratus	Marbled murrelet
Cepphus columba	Pigeon guillemot
Cerorhinca monocerata	Rhinoceros auklet
Cyclorrhynchus psittacula	Parakeet auklet
Fratercula cirrhata	Tufted puffin
Fratercula corniculata	Horned puffin
Larus argentatus	Herring gull
Larus canus	Mew gull
Larus glaucescens	Glaucus-winged gull
Larus hyperboreus	Glaucus gull
Larus philadelphia	Bonaparte's gull
Larus tridactyla	Black-legged kittiwake
Stercorarius longicaudus	Long-tailed jaeger
Stercorarius parasiticus	Parasitic jaeger
Stercorarius pomarinus	Pomarine jaeger
Sterna aleutica	Aleutian tern
Sterna paradisaea	Arctic tern
Synthliboramphus antiquus	Ancient murrelet
Uria aalge	Common murre
Uria lomvia	Thick-billed murre
Xema sabini	Sabine's gull
Order: Ciconiiformes - Family: Phalacrocoracidae	
Phalacrocorax auritus	Double-crested cormorant
Phalacrocorax pelagicus	Pelagic cormorant
Phalacrocorax urile	Red-faced cormorant
Order: Ciconiiformes - Family: Podicipedidae	
Podiceps auritus	Horned grebe
Podiceps grisegena	Red-necked grebe
Podilymbus podiceps	Pied-billed grebe
Order: Ciconiiformes - Family: Procellariidae	
Diomedea albatrus	Short-tailed albatross

Fulmarus glacialis	Northern fulmar
Oceanodroma furcata	Fork-tailed storm-petrel
Oceanodroma leucorhoa	Leach's storm-petrel
Puffinus griseus	Sooty shearwater
Puffinus tenuirostris	Short-tailed shearwater
Order: Ciconiiformes - Family: Scolopacidae	
Actitis macularia	Spotted sandpiper
Aphriza virgata	Surfbird
Arenaria interpres	Ruddy turnstone
Arenaria melanocephala	Black turnstone
Calidris alpina	Dunlin
Calidris bairdii	Baird's sandpiper
Calidris canutus	Red knot
Calidris mauri	Western sandpiper
Calidris melanotos	Pectoral sandpiper
Calidris minutilla	Least sandpiper
Calidris ptilocnemis	Rock sandpiper
Calidris pusilla	Semipalmated sandpiper
Capella gallinago	Common snipe
Heteroscelus incanus	Wandering tattler
Limnodromus	Dowitcher
Limnodromus griseus	Short-billed dowitcher
Limnodromus scolopaceus	Long-billed dowitcher
Limosa fedoa	Marbled godwit
Limosa haemastica	Hudsonian godwit
Limosa lapponica	Bar-tailed godwit
Numenius phaeopus	Whimbrel
Phalaropus fulicarius	Red phalarope
Phalaropus lobatus	Red-necked phalarope
Tringa flavipes	Lesser yellowlegs
Tringa melanoleuca	Greater yellowlegs
Tringa solitaria	Solitary sandpiper
Order: Columbiformes - Family: Columbidae	
Columba livia	Rock dove
Order: Coraciiformes - Family: Cerylidae	
Ceryle alcyon	Belted kingfisher
Order: Galliformes - Family: Phasianidae	
Dendragapus canadensis	Spruce grouse
Lagopus lagopus	Willow ptarmigan
Lagopus mutus	Rock ptarmigan
Order: Galliformes - Family: Tetraonidae	
Canachites canadensis	Spruce grouse
Order: Gruiformes - Family: Gruidae	
Grus canadensis	Sandhill crane
Order: Gruiformes - Family: Rallidae	
Fulica americana americana	American coot
Order: Passeriformes - Family: Alaudidae	
Eremophila alpestris	Horned lark
Order: Passeriformes - Family: Bombycillidae	
Bombycilla garrulus	Bohemian wagwing

Order: Passeriformes - Family: Certhiidae	
Certhia americana	Brown creeper
Order: Passeriformes - Family: Troglodytidae	
Troglodytes troglodytes	Winter wren
Order: Passeriformes - Family: Cinclidae	
Cinclus mexicanus	American dipper
Order: Passeriformes - Family: Corvidae	
Corvus caurinus	Northwestern crow
Corvus corax	Common raven
Nucifraga columbiana	Clark's nutcracker
Perisoreus canadensis	Gray jay
Pica pica	Black-billed magpie
Order: Passeriformes - Family: Fringillidae	
Calcarius lapponicus	Lapland longspur
Carduelis flammea	Common redpoll
Carduelis hornemanni	Hoary redpoll
Carduelis pinus	Pine siskin
Dendroica coronata	Yellow-rumped warbler
Dendroica petechia	Yellow warbler
Dendroica striata	Blackpoll warbler
Euphagus carolinus	Rusty blackbird
Junco hyemalis	Dark-eyed junco
Junco hyemalis hyemalis	Slate-colored junco
Loxia curvirostra	Red crossbill
Loxia leucoptera	White-winged crossbill
Melospiza melodia	Song sparrow
Molothrus ater	Brown-headed cowbird
Passerculus sandwichensis	Savannah sparrow
Passerella iliaca	Fox sparrow
Pinicola enucleator	Pine grosbeak
Plectrophenax hyperboreus	Mckay's bunting
Plectrophenax nivalis	Snow bunting
Seiurus noveboracensis	Northern waterthrush
Spizella arborea	American tree sparrow
Vermivora celata	Orange-crowned warbler
Wilsonia pusilla	Wilson's warbler
Zonotrichia atricapilla	Golden-crowned sparrow
Zonotrichia leucophrys	White-crowned sparrow
Order: Passeriformes - Family: Hirundinidae	
Hirundo pyrrhonota	Cliff swallow
Hirundo rustica	Barn swallow
Riparia riparia	Bank swallow
Tachycineta bicolor	Tree swallow
Tachycineta thalassina	Violet-green swallow
Order: Passeriformes - Family: Laniidae	
Lanius excubitor	Northern shrike
Order: Passeriformes - Family: Muscicapidae	
Catharus fuscescens	Veery
Catharus guttatus	Hermit thrush

Catharus minimus	Gray-cheeked thrush
Catharus ustulatus	Swainson's thrush
Turdus	Robin
Turdus migratorius	American robin
Order: Passeriformes - Family: Paridae	
Parus atricapillus	Black-capped chickadee
Parus hudsonicus	Boreal chickadee
Order: Passeriformes - Family: Passeridae	
Anthus rubescens	American pipit
Anthus spinoletta rubescens	Water pipit
Motacilla flava	Yellow wagtail
Order: Passeriformes - Family: Regulidae	
Regulus calendula	Ruby-crowned kinglet
Regulus satrapa	Golden-crowned kinglet
Order: Passeriformes - Family: Sittidae	
Sitta canadensis	Red-breasted nuthatch
Order: Passeriformes - Family: Sturnidae	
Sturnus vulgaris	European starling

Order: Passeriformes - Family: Turdidae	
Ixoreus naevius	Varied thrush
Order: Passeriformes - Family: Tyrannidae	
Contopus borealis	Olive-sided flycatcher
Empidonax alnorum	Alder flycatcher
Empidonax difficilis	Pacific-slope flycatcher
Empidonax traillii	Willow flycatcher
Sayornis saya	Say's phoebe
Order: Piciformes - Family: Picidae	
Colaptes auratus	Northern flicker
Picoides pubescens	Downy woodpecker
Picoides tridactylus	Three-toed woodpecker
Order: Strigiformes - Family: Strigidae	
Aegolius funereus	Boreal owl
Asio flammeus	Short-eared owl
Bubo virginianus	Great horned owl
Strix nebulosa	Great gray owl
Surnia ulula	Northern hawk owl

Aerial surveys of random sample plots of habitat thought to contain swan habitat were flown on the Alaska Peninsula in 1991 to derive population estimates (USFWS 1991), and Wilk (1988) conducted aerial surveys to document Tundra Swan distribution, abundance, population structure, and productivity in Bristol Bay. The Tundra Swan surveys included some western portions of KATM.

Some of the landbird and inland waterbird species more commonly recorded in anecdotal sighting records in recent years at Brooks River (late spring through fall) and during the VTTS BBS include Common Loon, Red-necked Grebe, Tundra Swan, Green-winged Teal, Mallard, American Wigeon, Greater Scaup, Harlequin Duck, Common Goldeneye, Barrow's Goldeneye, Common Merganser, Red-breasted Merganser, Osprey, Bald Eagle, Northern Harrier, Northern Goshawk, Spruce Grouse, Rock Ptarmigan, Willow Ptarmigan, Semipalmated Plover, Greater Yellowlegs, Spotted Sandpiper, Black Turnstone, Surfbird, Common Snipe, Great-horned Owl, Belted Kingfisher, Downy Woodpecker, Three-toed Woodpecker, Tree Swallow, Violet-green Swallow, Bank Swallow, Gray Jay, Black-billed Magpie, Common Raven, Black-capped Chickadee, Boreal Chickadee, Brown Creeper, American Dipper, Golden-crowned Kinglet, Ruby-crowned Kinglet, Gray-cheeked Thrush, Swainson's Thrush, Hermit Thrush, American Robin, Varied Thrush, American Pipit, Orange-crowned Warbler, Yellow-rumped Warbler, Blackpoll Warbler, Northern Waterthrush, Wilson's Warbler, American Tree Sparrow, Savannah Sparrow, Golden-crowned Sparrow, White-crowned Sparrow, Dark-eyed Junco, Snow Bunting, White-winged Crossbill, and Common Redpoll. Other landbird and inland waterbird species commonly noted in NPS staff reports for the KATM coast include Black Scoter, White-winged Scoter, Surf Scoter, Northwestern Crow, Yellow Warbler, and Fox Sparrow (LaFrance and Peterson 1991; Litch and Blackie 1988; Starr and Starr 1992)

Surveys of seabirds nesting along the coast of KATM were conducted in 1973, 1981, 1988, 1989, 1993, and 1994 (Bailey and Faust 1984, Litch and Blackie 1988, Martin 1989, R. Potts KATM unpubl. data 1993, Goatcher 1994a). Black-legged kittiwakes, tufted puffins, horned puffins, Glaucus-winged Gulls, and Pigeon Guillemots are the dominant breeding seabirds. Twenty-eight colonies have been identified but approximately 70% of the seabirds nest on Ninagiak and Shaw Islands (Bailey and Faust 1984). Cliff-nesting cormorants and kittiwakes concentrate at five locations: Shakun, Kukak, Gull, Takli, and Katmai (Goatcher 1994a). Harlequin ducks occur along most of the Katmai coastline. Martin (1989) reported 1,360 Harlequins during population counts in summer 1989 and Goatcher (1994b) reported 1,646 in 1994. Goatcher et al. (1999) marked Harlequins along the Katmai coastline in 1996-97 to determine whether aggregations of individuals within local areas of the marine environment are discrete and demographically independent from populations in Prince William Sound.

Peregrine falcon.—Although sightings are infrequent, Peregrine Falcon sightings have been typically reported in KATM coastal patrol reports. White et al. (1993) reported that Peregrine nests have only been confirmed or were probable in 2 coastal areas of KATM (Cape Douglas and Amalik Bay). The Amalik Bay nest was observed in 1992 (Starr and Starr 1992). Bailey and Faust (1984) observed only one active peregrine nest, and two other suspected nests during a boat-based survey of the KATM coast in 1981. An aerial survey to evaluate habitat within the park where Peregrine Falcons might occur, and to locate nests, was conducted in 1993 (White et al. 1993). One possible coastal nest was located during that survey. Occasional anecdotal sightings of Peregrines have been recorded on sighting forms, primarily along the KATM coast. None of the KATM sighting records specify subspecies.

Bald Eagle and Golden Eagle.—Nesting Bald Eagles are relatively common in KATM, primarily along the coast and along inland lakes and rivers. Aerial Bald Eagle surveys were conducted annually in the Park between 1974 and 1980 (Troyer 1974b, 1975b, 1976b, 1977c, 1978b, 1979, 1980c) and since 1983 similar surveys have been periodically carried out along specific inland lakes and streams where eagles are most likely to be subject to human disturbance (Jope and Starr 1983; Jope 1984b, 1985b, 1986b, 1987; Sowl 1988, Squibb 1992, Savage 1993, 1994, 1997). In a few of these years, nests were also resurveyed for productivity. Extensive coastal Bald Eagle population and productivity surveys were conducted between 1989 and 1992 in response to the Exxon Valdez oil spill (Yurick 1989; Portner 1991). An adult Bald Eagle survey of the entire Alaska Peninsula was conducted by USFWS during late April 2000. The stratified random plot quadrat sampling included 3 sample plots along the KATM coast (Savage and Hodges 2000).

Golden Eagles are occasionally observed in mountainous areas of KATM. An active Golden Eagle nest, and another inactive nest were documented in KATM

in 1993 during an aerial survey to locate peregrine falcon nests (White et al. 1993).

Terrestrial Threatened and Endangered Species

Currently no federally listed species are known to occur in terrestrial areas of KATM. The USFWS formerly listed some wildlife species as category 2 candidate species, which indicated that further research was needed to assess biological vulnerability, taxonomy and/or threats. This designation was discontinued in 1996, and those species are now referred to by the USFWS as "species of concern." Federal bird species of concern that occur in terrestrial areas of KATM include the Harlequin Duck, and Olive-sided Flycatcher. The American Peregrine Falcon was delisted in 1999, but will be listed by the USFWS as a species of concern for a monitoring period of five years. American Peregrine Falcon, Olive-sided Flycatcher, Gray-cheeked Thrush, and Blackpoll Warbler are State of Alaska Species of Special Concern that have been documented or are thought to occur in KATM.

As indicated above, Peregrine Falcons have infrequently been sighted in KATM, and observations of nesting Peregrine Falcons are limited to a few along the coast. Harlequin Ducks have been documented in anecdotal sighting records on several inland streams in KATM including Brooks River, Moraine Creek, and Funnel Creek (KATM unpubl. data, Olson et al. 2003) and are common along the coast (Martin 1989, Goatcher 1994b). A single observation of an Olive-sided Flycatcher was recorded during a breeding bird survey of the VTTS road in 1994 (S. Savage, KATM, unpubl. data). Gray-cheeked Thrush and Blackpoll Warbler have been recorded in all years in which breeding bird surveys were conducted along the VTTS road (S. Savage, KATM, unpubl. data).

Natural Resource Management Issues

- **Discharge of water pollutants-** At Brooks Camp, soils and ground water have been contaminated by a leaking NPS fuel distribution system. Remediation of groundwater at Brooks Camp began in September 1998. In 1996, low levels of polycyclic aromatic hydrocarbons (PAHs) were found at Grosvenor Lodge, and sediment and water samples collected at a former U.S. Air Force recreation area within the park contained elevated concentrations of hydrocarbons (Johnson and Berg 1999).

- **Petroleum development, storage, and transportation-** Field work by the U.S. Geological Survey in 1979 and 1980 revealed promising petroleum exploration targets in the Shelikof Strait (Smith and Petering, 1981). Presently, both the state and federal governments are planning to sell oil and gas leases near the Katmai coast (U.S. National Park Service, 1994), with federal lease sales for the lower Cook Inlet, including offshore of Kamishak

Bay, scheduled for 2004 and 2006. State lease sales for upland and marine tracts are scheduled in 2004, 2005, and 2006.

The strong currents and high tidal ranges along the Alaskan coast can transport oil spills great distances from their source. During the *Exxon Valdez* oil spill of March 24, 1989, Katmai's coast received the greatest impact of the NPS units (U.S. National Park Service, 1990). Numerous petroleum facilities occur along the north gulf coast. The Valdez terminal in Prince William Sound receives approximately 24 billion gallons of oil per year via the TransAlaska Pipeline. There are also 15 production platforms operating in Cook Inlet. The Drift River Marine Terminal is a privately owned offshore oil loading platform in Cook Inlet with an onshore storage facility. The Nikiski oil terminal and refinery is located on the Eastern Shore of Cook Inlet. These two oil-loading facilities transfer over 3.3 billion gallons of oil per year (Potts et al., 1993).

- **Erosion and streambed alteration from boats-** Increased rate of erosion and alteration of streambed morphology have been found in American Creek and on the Alagnak River as a result of jet boat use (USNPS 1994; Dorava 1998a, b). Jet boat operation can also lead to significant salmonids embryo mortality (Horton 1994). In 1999, a more comprehensive 3-year study of erosion and its effects on water quality on the Alagnak River was initiated under a NPS/U.S. Geological Survey partnership.

- **Commercial developments-** Seven backcountry lodges exist within Katmai NP&P, and at least four more are being developed or planned on private inholdings, including the Alagnak Wild River, Naknek River and along the coast (Johnson and Berg 1999). The U.S. National Park Service (1994) identified several on-going activities that could affect natural resources in Katmai's backcountry including camping in high use areas, and boat, aircraft and ATV use.

- **Commercial, Sport, and Subsistence Fish Harvest-** Humans intercept and harvest many returning salmon and other fish in commercial, subsistence, and recreational fisheries. Harvesting of salmon, especially in the commercial fishery, represents the greatest threat to their populations, populations of other wildlife, and their natal ecosystems, which depend on them for food and the cycling of nutrients. Crab pot, salmon seine, long-line, scallop, bottom-dragger, and open-ocean trawl commercial fishing, as well as commercial urchin diving all occur along the Shelikof Strait. Pollock stocks in the Shelikof Straits area were decimated by overfishing in the 1980's.

- **Recreational Use-** Although visitation occurs throughout KATM, it is typically focused in small areas such as the most accessible sections of fishing streams. The result is a pattern of intensive use of numerous widely dispersed areas. Bear viewing has become an increasingly popular activity

along some salmon streams and especially along the Katmai coast.

- **Air pollutants-** The Resource Management Plan for Katmai National Park identified several threats to air quality in the park (USNPS 1994:150). These included: automobile and air traffic from King Salmon and Naknek, smoke from incinerators, dumps, fireplaces, wood-burning stoves, and furnaces in the local area, power generation from King Salmon, Naknek and local communities, regional pollution from Dillingham and Kodiak, campfires at Brooks Camp and backcountry site, and long distance transport from industrial areas

- **Global Warming-** Katmai's environment is thought to be very susceptible to climate change. Changes in the thermal regime can extend ice-free seasons, usually leading to increases in the ratio of evaporation + evapotranspiration to precipitation, and result in less water in the landscape (Schindler 1997). Climate also has a great influence on peatlands, which are found in Katmai's lowlands (Belland and Vitt 1995).

ECOLOGICAL PROFILE
KENAI FJORDS NATIONAL PARK

Physical Environment

Climate

Warm ocean currents flowing through the Gulf of Alaska result in a climate characterized by cool summers and winters mild for the latitude. The park, divided by the Kenai Mountains, lies in both the maritime and transitional Cook Inlet zone.

The coast has a typical maritime climate, with cool rainy summers and snowy, storm driven winters. The occasional calm sunny day is a treat to be savored. Steep mountains rising straight from sea level to over 5000 feet force moisture laden storms to rise, where cooling temperatures and subsequent loss of moisture holding capacity cause the clouds to drop massive loads of snow onto the Harding Icefield. It receives 400 inches of snowfall annually and is snow covered year round (USNPS 1999a). In contrast, mean annual snowfall for the area is approximately 50 inches. Snow cover occurs at sea level from November to late May and may linger on upper slopes until late August.

Annual precipitation in the Maritime zone is about 60 inches with 100 wet days per year and 32 inches of precipitation occurring from mid-July to late-December (USNPS 1999a). Rainfall is heaviest in Aialik Bay ranging from 45-80" during summer months of the 1990 decade, decreasing somewhat along the coast to the west. Aialik Bay frequently gets 3-4" of rainfall in one day, and August 20, 1993 recorded a memorable 10.55" (USNPS 1999b).

Geology

The outer coast of Kenai Fjords rides the exposed edge of the North American Plate where the Pacific Plate is “diving” beneath the North American plate. As a result, it is subject to earthquakes of moderate frequency and intensity, with resulting ocean floor landslides and terrestrial uplift and subsidence. A recent compilation (Haeusser and Plafker 1995) indicates a dozen earthquakes in the region of Kenai Fjords of magnitude 6.0 or greater during the past century. The beautiful circular bays of the Aialik, Harris and McCarty Peninsulas are drowned cirques of the Chugach Mountains, which were partially submerged by tectonic subsidence during the Holocene (Hamilton and Nelson 1989).

The bedrock of the Resurrection Peninsula and the Kenai Fjords coast is a mixture of faulted metamorphics and intruded volcanics. An arc of cretaceous upper Jurassic rocks stretches from Kenai Fjords near Gore Point around

through the Chugach Mountains, as far east as Glacier Bay. These rocks are primarily “grawyacke, slate, argillite, minor conglomerates, volcanic detritus and interbedded mafic volcanic rocks” (Beikman 1980). Several granite and granodiorite intrusions are scattered along the coast; examples are the southern ends of the McCarthy and Harris Peninsulas. This arc of metamorphic rocks with quartz veins host gold-bearing arsenopyrite. (Richter 1970).

The epicenter of the 1964 “Great Alaska Earthquake” was 95 miles NE of the town of Seward, and 100-150 miles from the coast of Kenai Fjords. Land at Seward subsided about 3 feet, and abundant evidence at the heads of the fjords would suggest similar subsidence along the coast west of Resurrection Bay. Additional lowering of the land surface at Seward was caused by underwater landslides in the fine-grained silts and clays deposited at the head of Resurrection Bay. Similar landslides (and tsunamis) may have occurred in Beauty Bay and North Arm of the McCarty Fjord at the western end of the park. However, most of the fjords have very steep bedrock walls or tidewater glaciers at their heads, and lack sediment buildups.

Saltwater intrusion and tidal flooding have converted freshwater wetlands and spruce forest bands throughout the fjords to tidal marshes and “ghost forests”, indicating terrestrial subsidence. These areas are evident in Beauty Bay, North Arm, near Delight Lake and James Lagoon, all part of the Nuka Bay complex, as well as the outer beaches of Northwestern Lagoon. Many of the coves and bays of Aialik Bay, Bulldog Cove and the coast offshore of Bear Glacier also show signs of subsidence, as do beaches throughout the islands and coasts of Resurrection Bay.

Pleistocene and Holocene glaciations are among the major forces in shaping the land and ecological processes of the Kenai Fjords coastline. Warming and cooling cycles over the past (at least) 100,000 years have resulted in multiple glacial advances and retreats. Glaciers that have covered Kenai Fjords have swept down from the Alaska and Aleutian ranges, or more recently, from the Harding Icefield capping the lower Kenai Mountains. Global cooling trends lower snowline and increase snow deposition in high terrain. Karlstrom (1964) shows ice sheets of Naptown age (7000-1100 yrs BP) completely covering much of the Alaska Range, Cook Inlet, Kodiak, Shelikof Straits, and the southeastern Kenai Peninsula. Although the locations of the terminal moraines are unknown, Karlstrom shows the ice extending 50-100 miles into the Gulf of Alaska beyond the current coastline. These glaciations completely covered the Kenai Mountains, indicating ice in excess of a mile thick. Moving ice over a mile deep exerts powerful forces on the terrain beneath it, and has carved off all soft and loose material, leaving steep polished bedrock walls and deep submarine valleys all along the Kenai coast.

More recent glaciations, although impressive in their impacts on the landscape, are mere whimpers in the scheme of glacial cycles. The latest glacial advances

apparently reached their maximal extent in the 19th century, and are currently undergoing a fairly dramatic retreat. Nearly 40 outlet glaciers flow off the Harding Icefield, with seven of these terminating as tidewater glaciers in Aialik, Northwestern and McCarty fjords. Approximately 100 yrs BP, these fjords were filled with glaciers that rested on terminal moraines miles seaward from their current termini. When a glacier retreats off the support provided by its terminal moraine, the floating ice sheet breaks up and retreats rapidly. McCarty Glacier has retreated 14.5 miles, and Northwestern and its associated glaciers have retreated over 9 miles since mapping by USGS in 1909 (Rice 1987). A rock outcrop has recently appeared in the face of Northwestern Glacier, indicating that its face may soon be grounded.

Hydrology

There are over 150 lakes and ponds in KEFJ with a combined surface area exceeding 4,200 acres (USNPS 1999a). Recent deglaciations have opened up new streams and lakes, which are rapidly colonized by salmon. Delight, Desire and Delusion (Delectable) Lakes on the east side of McCarty Fjord, are three of the larger lakes in KEFJ, and all are currently untilized by salmon. Icefree dates for these systems range from about 1920 for Delight to 1978 for Delusion (York and Milner 1999). Glaciers, such as Bear, Dinglestadt and Pederson,have silty lakes at their faces.

Freshwater streams on the Kenai Fjords coast tend to be short and very steep. Waterfalls abound, including an 800' falls above the North Arm of Nuka Bay. Streams in KEFJ are generally “flashy”, in that the flows respond rapidly to rain events, which can be extreme along this coast. Glacial streams, formed of meltwater from grounded and hanging glaciers, also tend to be short, but lower gradient than most of the clear water streams. Primary glacial streams flow into Nuka Bay, Northwestern Lagoon and Aialik Bay. The Nuka River receives drainage from numerous glaciers during its passage from Nuka Pass in the coastal range to sea level at Beauty Bay in the West Arm of Nuka Bay. Monthly discharge during one year of measurements ranged from a low of 34 cfs in April to 4005 cfs in July.

A brief report on water resources and hydrologic hazards in the Exit Glacier area was produced in 1985 (Sloan) and some limited water chemistry was done in streams below an unpatented mining claim in Nuka Bay. The Alaska Department of Fish and Game has conducted extensive limnological work on Delight and Desire Lakes in McCarty Fjord while assessing the potential to enhance existing salmon runs through lake fertilization (Edmundson et al. 1998, 2001).

Coastal/Marine

The Kenai Fjords coast is a series of deep narrow fjords cutting into the Kenai Mountains, spaced by even steeper rock cliffs along the exposed outer coast. Over a third of the park’s coast is impacted by high energy waves, primarily

driven by offshore winds and Gulf storms. An additional quarter is low and very low energy protected coves and lagoons (Table 1). Fjord waters in front of tidewater glaciers are usually dense with icebergs and brash ice which has calved off the glacier. Tides carry these bergs down-fjord many miles, but they seldom escape the main fjords into the Gulf. It is unlikely that the fjords freeze over during winter, although the lagoons and sheltered coves may build up shore ice in areas with fresh water influx. Sediment loads tend to be higher at the upper ends of fjords, where glacial waters are slow to mix with main Gulf waters.

Table 1. Energy regimes along Kenai Fjords coast. (From Mann 1995)

Energy Regime	Mileage	Percent
very low-lagoons	69	13
Low	51	10
Moderate	226	42
High	192	36

Tidal ranges for the coast are moderate, in the range of -3.2 to +14 feet. Several coastal lagoons (either formed or modified by the 1964 earthquake) provide marine estuary marshes along an otherwise rocky coast. Strong storms, especially when occurring at times of high tides, often drive surges of salt water or spray inland. A strong marine current swings along the outer coast from Prince William Sound around to Shelikof Strait. This current is the migratory highway for several species of whales, (and probably other species of marine mammals and fish). It also carries coastal detritus and incidental pollutants from east to west along the entire coast. Sea surface temperatures off the Kenai Fjords coast range from 40-55 ^{o}F throughout the year (Robinson 1957).

Biological Resources

Flora

Vegetation communities of the coast lands reflect the harsh environment, and Holocene glacial and tectonic events. Beginning at the intertidal and moving upward: sheltered waters contain stands of *Laminaria*, grading into *Fucus* in shallow mudflats exposed at low tides. An eelgrass bed grows in Pilot Bay of the North Arm of Nuka Bay. Gravel beaches grade into a supra-tidal community of beach ryegrass, beachpea and *Hockenyna* with scattered flowering forbs such as iris and jacob's ladder. Protected lagoons, like the backs of James and Beauty Bay have rich beds of goose tongue, a favorite spring food for bears. Exposed rocky cliffs have tufts of grasses and perennial forbs, some richly fertilized and aerated by puffin nests.

Alder stands and Sitka spruce/hemlock forests begin immediately above the

storm tide zone. Alder is a rapid invader in disturbed zones, following avalanche tracks from the alpine down to tide line. Scattered grasses and forbs find a foothold under the shrubs. Alder provides nitrogen for recently de-glaciated soils, enriching the environment for spruce invasion. Sitka spruce appears to move into de-glaciated terrain within 20 years of ice retreat (Rice and Spencer 1990). Recently developed Sitka spruce stands have uniform aged trees with a thin moss ground cover, scattered grasses and shrubs such as salmon berry and *Menziesia*. Older stands, growing through the last glacial maximum, have spruce of varying ages, a thick moss cover over the ground as well as on tree limbs, with alder, salmonberry and Devil's club in openings. A Sitka spruce cut down in Palisade Lagoon was over 700 years old and seven feet in diameter at the time of its death in 1990. It appears that there were spruce forest refugia perched in high valleys above the ice limits that are providing seed sources miles up-valley of the glacial terminus forests.

Alder thickets and open stands extend above the forested zone along the coast up to a narrow band of alpine tundra, which quickly grades into bare rock and ice. Glacial retreats have formed several wide valleys, with broad braided floodplains and stands of alder and willows on the coast, and the addition of cottonwood in the Exit Creek floodplain.

Glacial geologists have sampled interstadial trees in the fjords to help document forest occupation of these areas prior to glacial advance in neoglacial times (Wiles 1990). At Exit Glacier, a dendrochronological study of tree growth on glacial moraines documented minimum dates for occupation of the valley by Exit Glacier (Ahlstrand 1983). Transects of trails and roads in the Exit Glacier area have been established by seasonal resource management staff documenting human impacts in the vicinity of access routes. Research has also occurred on early succession on glacial till, including mycorrhizal colonization and patch formation (Helm, 1994).

Fauna

Fish

Although some fisheries surveys have been conducted in nearshore waters, there have been no systematic surveys for freshwater fish (Table 9). King, chum, coho, pink and sockeye salmon are known to spawn in numerous park streams. Dolly Varden are also known to be in park streams and lakes but their distribution throughout the park has not been documented.

The near shore pelagic realm supports many species of fish, including rock fish, halibut, ling cod, pollock, and char. Forage fish, such as caplin and herring, and several species of shrimp abound. Commercial fishing for salmon and halibut occurs in the fjords and in lagoons such as James and McCarty in McCarty Fjord.

Delight and Desire Lakes, and to a lesser extent, Delusion Lake, in McCarty Fjord have been the subject of several studies and publications (York and Milner 1999; Milner 1997) due to their large runs of anadromous fish (ADF&G 1992) and recent (20th century) emergence from glaciation.

Table 9. Fish Species – Kenai Fjords (NPSpecies 2003)

Scientific Name	Common Name	Status
Order: Clupeiformes - Family: Clupeidae		
Clupea harengus pallasii	Pacific herring	Probably Present
Order: Cypriniformes - Family: Catostomidae		
Catostomus catostomus	longnose sucker	Probably Present
Order: Gadiformes- Family: Gadidae		
Eleginus gracilis	saffron cod	Probably Present
Gadus macrocephalus	Pacific cod	Probably Present
Microgadus proximus	Pacific tomcod	Present in Park
Theragra chalcogramma	Alaska Pollock, walleye pollock	Present in Park
Order: Gadiformes- Family: Lotidae		
Lota lota	burbot	Present in Park
Order: Gasterosteiformes- Family: Gasterosteidae		
Gasterosteus aculeatus	Alaskan stickleback, threespine stickleback	Present in Park
Order: Lamniformes - Family: Lamnidae		
Lamna ditropis	salmon shark	Present in Park
Order: Osmeriformes- Family: Osmeridae		
Thaleichthys pacificus	eulachon	Present in Park
Order: Perciformes- Family: Bathymasteridae		
Bathymaster caeruleofasciatus	Alaskan ronquil	Present in Park
Order: Perciformes- Family: Zoarcidae		
Lycodopsis pacifica	blackbelly eelpout	Present in Park
Order: Perciformes- Family: Trichodontidae		
Trichodon trichodon	Pacific sandfish	Present in Park
Order: Petromyzontiformes- Family: Petromyzontidae		
Lampetra tridentata	Pacific lamprey	Probably Present
Order: Pleuronectiformes- Family: Pleuronectidae		
Atheresthes stomias	arrowtooth flounder	Present in Park
Glyptocephalus zachirus		Present in Park
Hippoglossoides elassodon	flathead sole	Present in Park
Hippoglossus stenolepis	Pacific halibut	Present in Park
Parophrys vetulus		Present in Park
Platichthys stellatus	starry flounder	Present in Park
Pleuronichthys decurrens	curlfin sole	Present in Park
Order: Rajiformes.- Family: Rajidae		
Raja rhina	longnose skate	Present in Park
Order: Salmoniformes- Family: Salmonidae		
Oncorhynchus gorbuscha	pink salmon	Present in Park
Oncorhynchus keta	chum salmon	Present in Park
Oncorhynchus kisutch	Coho salmon, silver salmon	Present in Park
Oncorhynchus mykiss	rainbow trout	Present in Park
Oncorhynchus nerka	sockeye salmon, red salmon, kokanee	Present in Park
Oncorhynchus tshawytscha	chinook salmon, king salmon	Present in Park
Prosopium cylindraceum	round whitefish	Present in Park
Salvelinus malma	dolly varden	Present in Park
Order: Scorpaeniformes- Family: Agonidae		
Agonus acipenserinus		Present in Park
Order: Scorpaeniformes - Family: Anoplopomatidae		
Anoplopoma fimbria	Sablefish	Present in Park
Order: Scorpaeniformes- Family: Cottidae		
Clinocottus acuticeps	sharpnose sculpin	Unconfirmed
Cottus aleuticus	coastrange sculpin	Present in Park
Cottus asper	prickly sculpin	Present in Park

Cottus cognatus	slimy sculpin	Present in Park
Dasycottus setiger	spinyhead sculpin	Present in Park
Leptocottus armatus	Pacific staghorn sculpin	Present in Park
Order: Scorpaeniformes- Family: Hexagrammidae		
Hexagrammos stelleri	whitespotted greenling	Present in Park
Order: Scorpaeniformes – Family: Scorpaenidae		
Sebastes ruber		Present in Park
Order: Squalidae – Family: Squalidae		
Squalus acanthias	piked dogfish, spiny dogfish	Probably Present

Terrestrial Mammals

Twenty nine species of terrestrial mammals are documented or are expected to occur within Kenai Fjords National Park (Table 10). Among these, mountain goat, moose, black bear, brown bear, hoary marmot, snowshoe hare, porcupine, ermine, red squirrel, and red-backed vole are the species most frequently encountered (KEFJ 1999). Also present, but less frequently observed, are wolves, coyotes, lynx, wolverine, marten, flying squirrel, beaver, river otter, little brown myotis bat, and mink (KEFJ 1999). The distribution, abundance, and breeding status of terrestrial mammal species in Kenai Fjords is, for the most part, unknown. Most information regarding terrestrial species in the park has come from anecdotal reports by park staff and visitors. There have been a small number of surveys on bats and microtines (Wright 2001), mountain goats (Tetreau 1989), moose (Everitt 2001) and an ongoing survey of mesocarnivore occurrence and distribution (Martin 2001).

Table 10: Mammal Species – KEFJ (NPSpecies 2003, KEFJ staff personal communications 2003)

Scientific Name	Common Name
Order: Artiodactyla - Family: Bovidae	
Oreamnos americanus	Mountain goat
Ovis dalli	Dall sheep
Order: Artiodactyla - Family: Cervidae	
Alces alces	Moose
Order: Carnivora - Family: Canidae	
Canis latrans	Coyote
Canis lupus	Wolf
Vulpes vulpes	Red fox
Order: Carnivora - Family: Felidae	
Lynx canadensis	Canadian lynx
Order: Carnivora - Family: Mustelidae	
Enhydra lutris	Sea otter
Gulo gulo	Wolverine
Lutra canadensis	River otter
Martes americana	Marten
Mustela erminea	Ermine
Mustela vison	Mink
Order: Carnivora - Family: Otariidae	
Callorhinus ursinus	Northern fur seal
Eumetopias jubatus	Stellar's sea lion

Order: Carnivora – Family: Phocidae	
Phoca vitulina	Harbor seal
Order: Carnivora - Family: Ursidae	
Ursus americanus	Black bear
Ursus arctos	Brown bear
Order: Cetacea – Family: Monodontidae	
Delphinapterus leucas	**beluga whale**
Order: Cetacea – Family: Balaenopteridae	
Balaenoptera acutorostrata	**minke whale**
Balaenoptera physalus	**fin whale**
Megaptera novaeangliae	**humpback whale**
Order: Cetacea - Family: Delphinidae	
Orcinus orca	**killer whale**
Order: Cetacea - Family: Eschrichtiidae	
Eschrichtius robustus	**gray whale**
Order: Cetacea - Family: Phocoenidae	
Phocoena phocoena	Harbor porpoise
Phocoenoides dalli	Dall porpoise
Order: Chiroptera - Family: Vespertilionidae	
Myotis californicus	California myotis
Myotis lucifugus	Little brown bat

Order: Insectivora - Family: Soricidae	
Microsorex hoyi	Pygmy shrew
Sorex cinereus	Masked shrew
Sorex monticolus	Montane shrew
Sorex pacificus	Pacific shrew
Order: Lagomorpha - Family: Leporidae	
Lepus americanus	Snowshoe hare
Order: Rodentia - Family: Castoridae	
Castor canadensis	Beaver
Order: Rodentia - Family: Dipodidae	
Zapus hudsonius	Meadow jumping mouse
Order: Rodentia - Family: Erethizontidae	
Erethizon dorsatum	Porcupine

Order: Rodentia - Family: Muridae	
Clethrionomys rutilus	Red-backed vole
Microtus miurus	Singing vole
Microtus oeconomus	Tundra vole
Microtus pennsylvanicus	Meadow mouse
Ondatra zibethicus	Muskrat
Synaptomys borealis	Northern bog lemming
Order: Rodentia - Family: Sciuridae	
Glaucomys sabrinus	Northern flying squirrel
Marmota caligata	Hoary marmot
Spermophilus columbianus	Columbian ground squirrel
Tamiasciurus hudsonicus	Red squirrel

Marine Mammals

The Gulf current provides a migratory path for humpback, grey, Minke and fin whales in spring and fall. A few humpbacks linger and feed on krill in Resurrection Bay, Harris Bay and the West Arm of Nuka Bay (Rice 1989). A quasi-resident pod of killer whales frequents outer Resurrection Bay. Dall's porpoises are frequently sighted at the mouths of the fjords, usually riding the bow wave of vessels. Harbor seals congregate at the upper ends of Aialik, Northwestern and McCarty fjords for pupping and molting on the ice from tidewater glaciers. The largest sea lion rookeries are on exposed slanted rocks at the surf line on the Pye and Chiswell Islands. Although much of the pupping and breeding activities take place in the Maritime Refuge, sea lions use Kenai Fjords rocks as haul outs in smaller numbers. Major feeding and hang out areas for sea otters are the submerged moraines in Aialik, Northwestern and McCarty fjords, and the sheltered covers and lagoons of Nuka Bay.

Birds

Two hundred eighteen species of birds are documented or expected to occur within Kenai Fjords National Park (Table 11). Nearly all surveys and research on birds have focused on seabirds and shore nesting species (Bailey, 1976; Rice, 1983; Nishimoto and Rice, 1987; Vequist and Nishimoto, 1990; Tetreau, 2002). The species most commonly observed by Wright (2001) were Wilson's Warbler, Varied Thrush, Hermit Thrush, Fox Sparrow, Ruby-crowned Kinglet and Orange-crowned Warbler. Other passerine (songbird) species commonly encountered include Steller's Jay, Black-billed Magpie, Northwestern Crow, Common Raven, Chestnut-backed and Black-capped Chickadee, Common Redpoll, Snow Bunting, White-winged Cross bill, and Dark-eyed Junco. Raptor species include Bald Eagle, Golden Eagle, Northern Goshawk, Sharp-shinned Hawk, and Great horned Owl. Additionally, Willow Ptarmigan, Rock Ptarmigan, White-tailed Ptarmigan, and Spruce Grouse are present in upland areas of the park.

Table 11: Bird Species – KEFJ (NPSpecies, 2003)

Scientific Name	Common Name
Order: Anseriformes - Family: Anatidae	
Anas acuta	Northern pintail
Anas americana	American wigeon
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas penelope	Eurasian wigeon
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anser albifrons	Greater white-fronted goose
Aythya affinis	Lesser scaup
Aythya collaris	Ring-necked duck
Aythya marila	Greater scaup
Aythya affinis	Lesser scaup
Aythya valisineria	Canvasback
Branta bernicla	Brant
Branta canadensis	Canada goose
Bucephala albeola	Bufflehead
Bucephala clangula	Common goldeneye
Bucephala islandica	Barrow's goldeneye
Chen caerulescens	Snow goose
Chen canagica	Emperor goose
Clangula hyemalis	Oldsquaw
Cygnus buccinator	Trumpeter swan
Cygnus columbianus	Tundra swan
Histrionicus histrionicus	Harlequin duck
Lophodytes cucullatus	Hooded merganser
Melanitta fusca	White-winged scoter
Melanitta nigra	Black scoter
Melanitta perspicillata	Surf scoter
Mergus merganser	Common merganser
Mergus serrator	Red breasted merganser
Polysticta stelleri	Steller's eider
Somateria mollissima	Common eider
Somateria spectabilis	King eider
Order: Ciconiiformes - Family: Accipitridae	
Accipiter gentilis	Northern goshawk
Accipiter striatus	Sharp-shinned hawk
Aquila chrysaetos	Golden eagle
Buteo jamaicensis	Red-tailed hawk
Buteo lagopus	Rough-legged hawk
Circus cyaneus	Northern harrier
Haliaeetus leucocephalus	Bald eagle
Pandion haliaetus	Osprey
Order: Ciconiiformes - Family: Ardeidae	
Ardea herodias	Great blue heron

Order: Ciconiiformes - Family: Charadriidae	
Charadrius hiaticula	Semipalmated plover
Charadrius semipalmatus	Plover
Charadrius vociferus	Killdeer
Haematopus bachmani	Black oystercatcher
Haematopus palliatus	American oystercatcher
Pluvialis dominica	Lesser golden plover
Pluvialis fulva	Pacific golden-plover
Pluvialis squatarola	Black-bellied plover
Order: Ciconiiformes - Family: Falconidae	
Falco columbarius	Merlin
Falco peregrinus	Peregrin falcon
Falco rusticolus	Gyrfalcon
Order: Ciconiiformes - Family: Gaviidae	
Gavia adamsii	Yellow-billed loon
Gavia arctica	Arctic loon
Gavia immer	Common loon
Gavia pacifica	Pacific loon
Gavia stellata	Red-throated loon
Order: Ciconiiformes - Family: Laridae	
Aethia cristatella	Crested auklet
Brachyramphus	Murrelet
Brachyramphus brevirostris	Kittlitz's Murrelet
Brachyramphus marmoratus	Marbled murrelet
Cepphus columba	Pigeon guillemot
Cerorhinca monocerata	Rhinoceros auklet
Aethia psittacula	Parakeet auklet
Fratercula cirrhata	Tufted puffin
Fratercula corniculata	Horned puffin
Larus argentatus	Herring gull
Larus canus	Mew gull
Larus glaucescens	Glaucous-winged gull
Larus hyperboreus	Glaucous gull
Larus philadelphia	Bonaparte's gull
Larus thayeri	Thayer's gull
Ptychoramphus aleuticus	Cassin's auklet
Rissa tridactyla	Black-legged kittiwake
Stercorarius longicaudus	Long-tailed jaeger
Stercorarius parasiticus	Parasitic jaeger
Stercorarius pomarinus	Pomarine jaeger
Sterna aleutica	Aleutian tern
Sterna caspia	Caspian tern
Sterna paradisaea	Arctic tern
Synthliboramphus antiquus	Ancient murrelet
Uria aalge	Common murre
Uria lomvia	Thick-billed murre
Xema sabini	

Order: Ciconiiformes - Family: Phalacrocoracidae	
Phalacrocorax auritus	Double-crested cormorant
Phalacrocorax pelagicus	Pelagic cormorant
Phalacrocorax urile	Red-faced cormorant
Order: Ciconiiformes - Family: Podicipedidae	
Podiceps auritus	Horned grebe
Podiceps grisegena	Red-necked grebe
Order: Ciconiiformes - Family: Procellariidae	
Diomedea immutabilis	Laysan albatross
Fulmarus glacialis	Northern fulmar
Oceanodroma furcata	Fork-tailed storm-petrel
Oceanodroma leucorhoa	Leach's storm-petrel
Puffinus griseus	Sooty shearwater
Puffinus tenuirostris	Short-tailed shearwater
Order: Ciconiiformes - Family: Scolopacidae	
Actitis macularia	Spotted sandpiper
Aphriza virgata	Surfbird
Arenaria interpres	Ruddy turnstone
Arenaria melanocephala	Black turnstone
Calidris alba	Sanderling
Calidris alpina	Dunlin
Calidris bairdii	Baird's sandpiper
Calidris mauri	Western sandpiper
Calidris melanotos	Pectoral sandpiper
Calidris minutilla	Least sandpiper
Calidris ptilocnemis	Rock sandpiper
Calidris pusilla	Semipalmated sandpiper
Gallinago gallinago	Common snipe
Heteroscelus incanus	Wandering tattler
Limnodromus griseus	Short-billed dowitcher
Limnodromus scolopaceus	Long-billed dowitcher
Limosa fedoa	Marbled godwit
Limosa haemastica	Hudsonian godwit
Limosa lapponica	Bar-tailed godwit
Numenius arquata	Far eastern curlew
Numenius phaeopus	Whimbrel
Phalaropus fulicaria	Red phalarope
Phalaropus lobatus	Red necked phalarope
Tringa flavipes	Lesser yellowlegs
Tringa melanoleuca	Greater yellowlegs
Tringa solitaria	Solitary sandpiper
Order: Columbiformes - Family: Columbidae	
Columba livia	Rock dove
Order: Coraciiformes - Family: Cerylidae	
Ceryle alcyon	Belted kingfisher
Order: Galliformes - Family: Phasianidae	
Dendragapus canadensis	Spruce grouse
Lagopus	Ptarmigan
Lagopus lagopus	Willow ptarmigan
Lagopus leucurus	White-tailed ptarmigan
Lagopus mutus	Rock ptarmigan
Order: Gruiformes - Family: Gruidae	
Grus canadensis	Sandhill crane
Order: Passeriformes - Family: Alaudidae	
Eremophila alpestris	Horned lark
Order: Passeriformes - Family: Bombycillidae	
Bombycilla garrulus	Bohemian wagwing
Order: Passeriformes - Family: Certhiidae	
Certhia americana	Brown creeper
Troglodytes troglodytes	Winter wren
Order: Passeriformes - Family: Cinclidae	
Cinclus mexicanus	American dipper
Order: Passeriformes - Family: Corvidae	
Corvus caurinus	Northwestern crow
Corvus corax	Common raven
Cyanocitta stelleri	Stellar jay
Perisoreus canadensis	Gray jay
Pica pica	Black-billed magpie
Order: Passeriformes - Family: Fringillidae	
Agelaius phoeniceus	Red-winged blackbird
Calcarius lapponicus	Lapland longspur
Carduelis flammea	Common redpoll
Carduelis hornemanni	Hoary redpoll
Carduelis pinus	Pine siskin
Dendroica coronata	Yellow-rumped warbler
Dendroica petechia	Yellow warbler
Dendroica striata	Blackpoll warbler
Dendroica townsendi	Townsend's warbler
Euphagus carolinus	Rusty blackbird
Fringilla montifringilla	Brambling
Junco hyemalis	Dark-eyed junco
Leucosticte arctoa	Rosy finch
Loxia curvirostra	Red crossbill
Loxia leucoptera	White-winged crossbill
Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow
Passerculus sandwichensis	Savannah sparrow
Passerella iliaca	Fox sparrow
Pinicola enucleator	Pine grosbeak
Plectrophenax nivalis	Snow bunting
Seiurus noveboracensis	Northern waterthrush
Spizella arborea	American tree sparrow
Vermivora celata	Orange-crowned warbler
Wilsonia pusilla	Wilson's warbler
Zonotrichia atricapilla	Golden-crowned sparrow
Zonotrichia leucophrys	White-crowned sparrow
Order: Passeriformes - Family: Hirundinidae	
Hirundo pyrrhonota	Cliff swallow
Hirundo rustica	Barn swallow
Riparia riparia	Bank swallow

Tachycineta bicolor	Tree swallow
Tachycineta thalassina	Violet-green swallow
Order: Passeriformes - Family: Laniidae	
Lanius excubitor	Northern shrike
Order: Passeriformes - Family: Muscicapidae	
Catharus guttatus	Hermit thrush
Catharus minimus	Gray-cheeked thrush
Catharus ustulatus	Swainson's thrush
Myadestes townsendi	Townsend's solitaire
Oenanthe oenanthe	Northern wheatear
Turdus migratorius	American robin
Order: Passeriformes - Family: Paridae	
Parus atricapillus	Black-capped chickadee
Parus hudsonicus	Boreal chickadee
Parus rufescens	Chestnut-backed chickadee
Order: Passeriformes - Family: Passeridae	
Anthus rubescens	American pipit
Order: Passeriformes - Family: Regulidae	
Regulus calendula	Ruby-crowned kinglet
Regulus satrapa	Golden-crowned kinglet
Order: Passeriformes - Family: Sittidae	
Sitta canadensis	Red-breasted nuthatch
Order: Passeriformes - Family: Sturnidae	
Sturnus vulgaris	European starling
Order: Passeriformes - Family: Turdidae	
Ixoreus naevius	Varied thrush
Order: Passeriformes - Family: Tyrannidae	
Contopus borealis	Olive-sided flycatcher
Contopus sordidulus	Western wood-pewee
Empidonax alnorum	Alder flycatcher
Sayornis saya	Say's phoebe
Tyrannus verticalis	Western kingbird
Order: Passeriformes - Family: Vireonidae	
Vireo gilvus	Warbling vireo
Order: Piciformes - Family: Picidae	
Colaptes auratus	Northern flicker
Picoides pubescens	Downy woodpecker
Picoides tridactylus	Three-toed woodpecker
Picoides villosus	Hairy woodpecker
Order: Strigiformes - Family: Strigidae	
Aegolius acadicus	Northern saw-whet owl
Aegolius funereus	Boreal owl
Asio flammeus	Short-eared owl
Bubo virginianus	Great horned owl
Nyctea scandiaca	Snowy owl
Otus kennicottii	Western screech-owl
Strix nebulosa	Great gray owl
Surnia ulula	Northern hawk-owl
Order: Trochiliformes - Family: Trochilidae	
Selasphorus rufus	Rufous hummingbird

The Chiswell and Pye Islands are nesting grounds for thousands of pelagic seabirds, including Tufted and Horned Puffins, Black-legged Kittiwakes, Murres, Pigeon Gillamonts, and three species of cormorants (Miller 1984). Smaller rookeries are found throughout the fjords, especially on the outer headlands, and rocky islands inside the fjords. Marbled Murrelets nest under glacial rocks and in old Sitka spruce along the coast. Black Oystercatchers scratch shallow nests into gravel beaches just above the tide-lines and protect them viciously from beachwalkers. Glaucous-winged Gulls are aggressively colonizing recently deglaciated islands in the fjords. Bald Eagles nest along the coast, averaging 50 active nests per year.

Terrestrial Threatened and Endangered Species

No federally listed species are known to occur in terrestrial portions of the park. However, several State of Alaska Species of Special Concern (ADF&G 2002) are present (Table 12). A State of Alaska Species of Special Concern is any species or subspecies of fish or wildlife or population native to Alaska that has entered a long-term decline in abundance or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance.

Table 12. Terrestrial Wildlife Species of Concern in the Exit Glacier Area (ADF&G 2002)

Common name	Species
Brown bear (Kenai Peninsula)	*Ursus Arctos*
Townsend's Warbler	*Dendroica townsendi*
Gray-cheeked thrush	*Catharus minimus*
Blackpoll warbler	*Dendroica striata*
Olive-sided flycatcher	*Contopus cooperi*

Natural Resource Management Issues

- **Access-** Corridors of impact exist in KEFJ along the Exit Glacier Road and Harding Icefield trail. Gravel extraction activities and the physical access routes themselves have the potential to alter hydrologic regimes

- **Mineral Extraction-** Park lands are fairly secure from new mineral extraction but significant problems exist at the site of past activities, particularly in Nuka Bay. Hydrology and vegetation have still not recovered in riparian areas. Reclamation may be required to regain more natural streambed alignment and grade as well as to encourage revegetation or erosion control.

- **Air Quality-** Although only limited air quality data has been collected, KEFJ is probably affected by long range transport of contaminants from the Far East. In addition, local and regional sources of contaminants may be of concern, particularly from oil refineries on the Kenai Peninsula and cruise ship emissions.

- **Oil and Gas Exploration, Transport and Production Activities-** Oil transport accidents from tankers travelling from the Port of Valdez have resulted in damage to the KEFJ coast in the past and the potential for a reoccurrence of a large spill are great. Smaller spills resulting from onboard fuel of commercial boats that run aground or sink and chronic, small spills from boats are yet another form of water borne contamination.

- **Hazardous Materials and Waste Management-** Hazardous waste on disturbed lands, especially mining claims, could be impacting water resources in the Nuka Bay area of the park. In 1997, high concentrations of arsenic at the Beauty Bay mine were stabilized. Staff are identifying hazards on abandoned mine lands in the park and contaminated soil remediation will continue in the future.

  Underground storage tanks are continually a threat to ground and surface waters. The park is working to get all USTs into federal and state compliance but the threat of undetected spills from old tanks is a concern.

- **Water Diversion for Bradley Lake Hydroelectric Power-** In June 1986 an agreement was signed with the Alaska Power Authority allowing diversion of melt water off the Nuka Glacier (outside NPS lands) into Bradley Lake for a hydro-electric power project. The agreement stipulates that 5 cfs will flow into the park's Nuka River. A diversion structure regulates the flow from the Nuka Glacier pool.

- **Recreational Use.** Visitor use has increased dramatically within the past 15 years, with 3 companies and approximately 15 vessels offering daily tours into the park. Many smaller charters run fishing trips to Resurrection and Ailalik Bays. Kayaking has become increasingly popular, frequently basing out of the four NPS public use cabins. Human waste, littering, bank erosion, and fuel spills are all areas of concern. Additonally, impacts of beach campers on the near shore meadows, oystercatchers, and black bears are currently being studied.

Ecological Profile
Lake Clark National Park and Preserve

Physical Environment

Climate

The Chigmit Mountains divide the subpolar marine climate of Cook Inlet from the continental climate of interior Alaska. Local climatic conditions within these two regimes vary with elevation and the distance from mountains and large bodies of water (USNPS 1999c).

The coastal east side of the mountains is typically warmer and wetter than the west side, with an annual average precipitation between15 to 20 inches. Precipitation increases dramatically, ranging between 40 to 80 inches per year, where the mountains immediately rise from Cook Inlet (LACL southeast coast). Mean coastal air temperature ranges from 10˚F to 32˚F during January, typically the coldest month. Mean temperature for the warmest month, July, ranges from 48˚F to 60˚F (USNPS 1983).

Port Alsworth, located west of the Chigmit Mountains, represents inland climate conditions. Annual precipitation at Port Alsworth is approximately 17 inches. Mean air temperature ranges from 12˚F in January to 56˚F in July. From 1960-1981, extreme air temperatures recorded at Port Alsworth were 86˚F and –55˚F (USNPS 1983).

Geology

The Chigmit Mountains are composed of a complex of multiple granitic stocks and batholiths that intruded after Triassic time into Paleozoic and Cenozoic rocks. The main batholith is elongated to the northeast, parallel to the structural trends of the region. The intruded rocks, which dip away from the Chigmits, are moderately to highly deformed volcanic and sedimentary rocks. Three volcanic piles of Teriary to Recent age are still active: Mount Spurr, Redoubt Volcano, and Ilamna Volcano (USNPS 1988).

The park has been extensively glaciated, with three known advances. All glacial deposits appear to be of Wisconsin age or younger (USNPS 1988).

Hydrology

Lake Clark National Park and Preserve (LACL) encompasses approximately 4 million acres of public and private lands in southwestern Alaska and contains over 6000 miles of rivers and streams - some of the most diverse water resources in the National Park system. The Alaska and Aleutian mountain ranges form a continuous watershed divide separating the coast from the interior.

Glacial ice, much of it associated with Redoubt and Iliamna volcanoes, covers approximately 30% of the park. Most of the glaciers in the park have retreated dramatically in the last four decades (USNPS 1999c). Silty meltwater from these glaciers and associated snowfields strongly influence the hydrologic cycle in the park.

The snow line in LACL begins between 4000 – 5000 ft msl on the east side of the mountain ranges and approximately 8000 ft msl on the west side (Karlstrom 1964). The overall absence of advanced forest at the higher elevations allows for little mitigation of runoff waters. Water quality from melt water in LACL is likely influenced by the bedrock (Dale and Stottlemyer 1986).

Permafrost is not prevalent in LACL, but it is found at considerable depth in isolated areas of predominately fine soils where insulation is high (Chamberlain 1989). Permafrost can impede precipitation from recharging aquifer systems, causing greater surface runoff to lakes and streams.

The headwaters for five major drainage basins are located within LACL's boundaries [the Kvichak River, Nushagak River, Kuskokwim River, Chakachatna River and Coastal basins]. LACL also includes the sixth largest lake in Alaska, Lake Clark, and three river segments designated as "Wild Rivers": Chilikadrotna (11 miles), Mulchatna (24 miles), and Tlikakila (51 miles) (USNPS 1999c).

Kvichak River Basin

The Kvichak River Basin drains Lake Clark (128 mi2) and Lake Iliamna, the largest lake in Alaska (1226 mi2). This 60-mile-wide basin extends northeastward from the northeast tip of Bristol Bay (Kvichak Bay) approximately 170 miles into the northwest slopes of the Aleutian Range. It also drains part of Katmai National Park and Preserve (Alagnak Wild River).

Lake Clark is the largest lake and most prominent geographic feature in the park (Table 13). Discharge from Lake Clark varies seasonally from 1060 – 42,370 ft3/s and is a major water source for the Kvichak River Basin (Demory et al. 1964). The northeast section of Lake Clark is fed by three principal tributaries: the Tlikakila River, Chokotonk River and Currant Creek. These three streams issue from glaciers and constitute approximately 60% (estimated from summer flow data) of the major stream input to Lake Clark (Demory et al. 1964). Otter Lake, located on the west side of the Tlikakila River, is a shallow lake with no inlet streams. Its short outlet stream drains into the Tlikakila.

Portage Creek is a small stream that enters Lake Clark from the north. A placer mining operation several miles upstream of the creek's mouth shows evidence of hydraulic methods (R. Kucinski, NPS Regional Office, personal communications., 2000).

Table 13. Area and maximum-recorded depth for major lakes located within Lake Clark National Park and Preserve (ADF&G and NPS 1980; area calculated with GIS unless otherwise noted.)

Lake	Area (mi^2)	Max recorded depth (feet)	Lake	Area (mi^2)	Max recorded depth (feet)
Caribou	0.5	ns	Pickerel, Lower	0.6	8
Crescent	5.7	ns	Portage	0.5	170
Fishtrap	0.9	78.5	Snipe	1.3	52.5
Hickerson	1.6	134.5	Tazimina, Upper	4.8	337
Kijik	1.6	325	Tazimina, Lower	2.8	203
Kontrashibuna	5.8	ns	Telaquana	17.7	>426.5[3]
Lachbuna	1.6	121	Turquoise	4.9	338
Lake Clark	128[1]	1056[2]	Twin, Upper	4.8	275.5
Otter		75.5	Twin, Lower	2.8	128
Pickerel, Upper	0.7	62	Two Lakes	4.9	>174[3]
Pickerel, Middle	1.2	7			

[1] data source (Brabets 2002), [2] data source (Wilkens 2002), [3] depth exceeded length of survey equipment, ns = not surveyed

The Kijik drainage consists of the Kijik River a glacial (turbid) stream, and the Little Kijik River, a clearwater stream. The Little Kijik River feeds Kijik Lake before joining the Kijik River. Portage, Lachbuna and Kijik Lakes are major water sources for the Kijik River. Clear and deep, Portage Lake was the most alkaline (total alkalinity as CaCO3 = 136 mg/L) of the lakes sampled within LACL in 1978 (ADF&G and USNPS 1980). Although Kijik Lake drops off sharply along its east and west sides, significant littoral areas on the north and south ends provide important salmon spawning habitat. Kijik Lake and the Little Kijik River compose the second largest red salmon spawning area in LACL.

The Tanalian River, a glacial stream that passes through Kontrashibuna Lake, enters Lake Clark just southwest of Port Alsworth. Tanalian Falls, approximately 0.5 miles downstream from Kontrashibuna Lake, is an impressive barrier that prevents salmon from migrating further upstream.

The Chulitna River drains tundra and lowlands and enters Lake Clark at Chulitna Bay, a large but shallow bay. The river is a long (approximately 90 miles) slow flowing stream (1.5 - 2.0 ft/sec) with a brownish color due to high organic content. In 1999, the U.S. Geological Survey calculated drainage area and measured discharges at the mouth of the Chokotonk River, Tlikakila River, Currant Creek, Kijik River, Tanalian River, and Chulitna River (Tables 14 and 15).

Table 14. Drainage area (mi^2) for Lake Clark and tributaries (Brabets 2002).

Lake Clark	Chokotonk River	Tlikakila River	Currant Creek	Kijik River	Tanalian River	Chulitna River
2942	168	622	165	298	205	1157

The Upper and Lower Tazimina Lakes feed the Tazimina River, where a hydroelectric facility was recently constructed in the preserve. The two lakes are the catch basins for a 350-mi2 watershed. The Pickerel Lakes (Upper, Middle, Lower) empty into Sixmile Lake via a short outlet stream. Caribou Lake, located

on the western preserve boundary, is one of several small lakes in the headwaters of the Koksetna River. This relatively small lake is primarily fed by snowmelt and springs from nearby alpine tundra hills (ADF&G and USNPS 1980).

Table 15. Discharge data (ft^3/sec) recorded in 1999 using Acoustic Doppler equipment (Brabets personal communications 2000).

Month 1999	Chokotonk River	Tlikakila River	Currant Creek	Kijik River	Tanalian River	Chulitna River
Mar	ns	25.3	Ns	ns	ns	ns
May	ns	510	Ns	ns	ns	ns
Jun	2190	ns	2670	1750	5920	4090
Jul	1200	ns	1590	857	1620	1400
Aug	1950	5850	1280	1130	1850	4060
Sep	ns	ns	885	758	650	3160
Oct	260	870	278	431	543	2200

Note: each value represents a single measurement collected at each stream mouth during the respective months. ns = not sampled

Nushagak River Basin

The Nushagak River Basin is approximately 220 miles long and 100 miles wide, and drains into Bristol Bay. Twin Lakes are the upper watershed source for the Chilikadrotna River, which flows southwesterly approximately 60 miles before joining the Mulchatna River. Only the Chilikadrotna's extreme upper section is included in LACL where mid-channel depths ranged from 3.3 – 8.2 feet and velocity averaged 3.3 ft/sec in 1978. The Twin Lakes occupy a glacial basin and are connected by approximately 0.3 miles of river. Fishtrap Lake is a major water source of the Little Mulchatna and Chilikadrotna rivers. Snipe Lake feeds a small tributary to the Chilikadrotna River (ADF&G and USNPS 1980).

Turquoise Lake is the initial headwater source for the Mulchatna River. The main inlet stream, which originates from a glacier several miles away, enters the eastern end of the lake. From Turquoise Lake, the Mulchatna River flows southwesterly approximately 217 miles to its confluence with the Nushagak River. In LACL, the river is approximately 50 meters wide with a recorded velocity of 3.3 ft/sec in 1978 as it meanders through a moraine deposit. The river increases in velocity through the Bonanza Hills as the gradient increases to 47 feet/mile (ADF&G and USNPS 1980).

Kuskokwim River Basin

This large basin is approximately 500 miles long and averages 100 miles in width. It drains into Kuskokwim Bay on the Bering Sea. The Merril River drains the west side of Merril Pass, a major flight line for western Alaska. It joins the Necons River above Two Lakes. Two Lakes is actually one lake, nearly bisected by a remnant glacial moraine. Below Two Lakes, the Necons flows into the Stony River, which joins the Kuskokwim River over 200 miles away.

Telaquana Lake, a 16-mi^2 lake, is the principal source of the Telaquana River. This deep lake has littoral habitat in the western and extreme eastern ends (inlet) of the lake. Telaquana River flows into and out of Telaquana Lake before joining the Stony River.

Coastal Drainage Basin

Along LACL's eastern boundary is the coastal drainage basin, which includes the Chakachatna River Basin. Streams along the coast drain the eastern mountain slopes to Cook Inlet (USDI 1952). The Chakachatna Basin is drained by the Neacola, Igitna, and Another rivers, which flow into Kenibuna Lake, located on the park's northeastern boundary, and on into Chakachamna Lake. Shamrock Glacier terminates in Kenibuna Lake. The Chilligan River originates in LACL, but joins Chakachamna Lake outside of the park boundary. The outlet for Chakachamna Lake is the Chakachatna River. Different channels of this river either flow directly into Cook Inlet or join the McArthur River before entering Cook Inlet.

The Drift River is a braided system that drains the Chigmit Mountains, including Redoubt Volcano, before emptying into Cook Inlet at Redoubt Bay. Crescent Lake lies in a glacially cut valley that feeds the Crescent River, and is the largest coastal lake in the park, The Crescent River empties into Cook Inlet just north of Tuxedni Bay, a sensitive salt marsh area. A large area of privately owned land along the lower reaches of the Crescent River is currently being logged.

Hickerson Lake is located on the southeastern slope of Iliamna Volcano. This snow-fed lake does not have a surface outlet (ADF&G and USNPS 1980). The Johnson River drains the glaciers and snowfields on the southeastern slope of Iliamna Volcano. An inholding within the upper watershed is the site of a proposed hard rock mine. Other coastal streams of significance include the West Glacier Creek, Red River, Silver Salmon Creek, and Shelter Creek. Several miles of the lower portions of the Tuxedni River, Johnson River and West Glacier Creek are tidally influenced.

Early limnological studies of the aquatic systems that include LACL were of a broad or general nature (Burgner et al. 1969; Mathisen and Poe 1969; ADF&G and USNPS 1980). A 3-year study of chemical, physical and biological characteristics of surface waters in the park, (Dale and Stottlemyer 1986; Stottlemyer and Chamberlain 1987; Chamberlain 1989), provided more specific water chemistry data on selected surface waters in LACL. The University of Alaska Fairbanks recently completed a limnological assessment of Lake Clark (Wilkens 2002).

USGS-WRD monitored water quality and runoff characteristics for the Tlikakila River and other major Lake Clark tributaries over three runoff seasons, 1999-2001. Although the Tlikakila watershed comprises 21percent of the Lake Clark

Basin, it contributes 37 to 47 percent of the total inflow. The river is a calcium to calcium magnesium bicarbonate water type with low buffering capacity. During the study period, it transported between 0.4 to 1.5 million tons of suspended sediment into Lake Clark. The resulting sediment plume makes the lake light-limited in terms of primary productivity. Monthly measurements of flow and water quality were also collected on the Chokotonk River, Chulitna River, Currant Creek, Kijik River and Tanalian River. Discharge measurements at the Lake Clark outlet (Newhalen River) provided additional data to produce a water budget for the lake (Brabets 2002). In 2001, USGS-WRD collected data on runoff components in the Tlikakila River Basin to determine the relative contributions of springs, glaciers, rainfall and snowmelt. Several airborne profiles of glaciers were flown to help construct a history of glacier change in the Basin. Preliminary results indicate that from 1957 to 1996, the glaciers have been thinning at an average rate of between 0.46 meters/year and 0.96 meters/year. However, the glaciers may be thickening from 1996 to 2001 (Brabets 2001a).

The University of Alaska at Fairbanks initiated a limnology study of Lake Clark in 1999 (Wilkens 2002). This study looked at the physical and chemical characteristics of Lake Clark to its full depth of 322 meters, and examined the zooplankton species and biomass in cooperation with contemporaneous studies on the tributaries and the sockeye salmon in the lake.

While most studies have focused on Lake Clark, water quality data have also been collected at the Johnson River, a coastal watershed explored in the 1980's and early 1990's for potential mineral extraction. During 1998-2001, Johnson River was included in the Cook Inlet National Water Quality Assessment Program. USGS operated a streamgage year round near the ore deposit site. These data provided a good overview of spring baseflow, snowmelt, and summer runoff conditions. Eighteen water samples (6 per year) were collected and analyzed for a number of constituents such as nutrients, trace elements, organic carbon, major ions, and suspended sediment. About 60 rock samples were collected near the ore deposit and analyzed for trace elements and their potential for acid mine drainage. Preliminary results indicate good water quality and a 'low acid-generating potential/high neutralizing potential' of the ore deposit (Brabets 2001b).

Coastal/Marine

The Lake Clark National Park (LACL) contains 130 miles of coastline in western lower Cook Inlet, a large tidal estuary with a length of 280 km and a width ranging from about 20 to 90 km. It is bordered on the west and northwest by the Alaska Range, on the northeast by the Talkeetna Mountains, and on the southeast by the Kenai-Chugach Mountains. Cook Inlet is an extremely dynamic, high-energy estuarine environment. The tides in the inlet are characterized by two highs and lows of unequal height in each period of approximately 25 hours (Dames and Moore, 1978). The normal tidal cycle, completed in just over 12

hours, has an average height ranging from about 5.5 m in Kachemak Bay to 8.8 m at Anchorage. Extreme high tides can be in excess of l 1 m, making the tidal ranges in Cook Inlet among the largest in the world (Britch 1976; Brower et al 1977).

The mean surface water temperature ranges from a high of 11.7 degrees (C) in July to 0.7 degrees (C) in January. The local weather is strongly influenced by the adjacent Chigmit Mountains and Aleutian Range. Dominant winds through Shelikof Strait and Cook Inlet are generally aligned with the trend of the shoreline (SW to NE) and no one direction prevails. Gales in this region generally last from 1-3 days without intermission (NOS, 1987). Seas and winds are generally much higher and stronger on the western side of the inlet particularly in the vicinity of the numerous capes and headlands (NOS, 1987).

The major sources of freshwater and sediment (from glacial erosion) to Western Lower Cook Inlet are the Drift River and Tuxedni River (Sharma 1979). Rainfall is another source of freshwater to the Inlet and several volcanoes contribute ash to the estuary. Freshwater flow into Cook Inlet varies seasonally. It is low in the winter and reaches a peak in July and August. Local areas of depressed salinity occur off the mouth of large glacially fed streams, such as the Tuxedni River (Freethey and Scully 1980).

The rivers emptying into Cook Inlet carry very high loads of suspended sediments, mainly fine glacial flour. The high tidal currents and turbulent mixing of the waters of the inlet prevent most of these suspended sediments from settling to the bottom. As a result, concentrations of suspended sediments in the waters of upper Cook Inlet are very high. Average concentrations of suspended sediments are about 200 mg/l with maximum concentrations in excess of 2,000 mg/l (Shanna and Burrell 1970, Feely and Massoth 1982). Fine-gained sediments are carried south through the lower Inlet and into Shelikof Strait and the outer continental shelf of the Gulf of Alaska. Schoch (1996) suggests that sediment transport direction along the LACL shoreline is south with counterclockwise transport in Tuxedni and Chinitna Bays.

Winter ice formation can be extensive in Tuxedni Bay and Channel. Estuary ice that forms in Tuxedni Bay is comprised of freshwater and is much harder than sea ice. Due to a combination of ice structure, lower air temperatures, and shelter from wind, this bay can remain ice covered for 3-4 months during winter (Bennett, pers obs). When the bay ice breaks up in late winter, ice flows that are moved by tides and winds gouge shorelines, cause shoreline erosion, and exert significant forces on offshore structures (B. Woods, pers comm).

Forty-three percent of the LACL coastline is either very protected or protected from high energy waves (Schoch 1996). Over half of this length includes the salt marshes of Tuxedni and Chinitna Bays. No portions of the LACL shoreline are fully exposed to the wave climate of the Gulf of Alaska; however, southeast storm

swells from the Gulf penetrate into Lower Cook Inlet during the winter months. These events cause very large berms to develop on boulder beaches in the semi-exposed regions.

Salt marsh accounts for 22% of the total shoreline length and 42% of the total intertidal area. The combined soft substrates (saltmarsh, sand and mud flats) account for 90% of the total length and 98% of the total area (Schoch 1996). Combinations of rocky shores (ramps, platforms, cliffs) are a very small percentage of the total habitat type on the LACL coastline.

In 1991-92, the Coastal Programs Division of the Alaska Support Office acquired black and white aerial photography at 1:24,000 scale (enlarged to 1:12,000) for the entire coastline of Lake Clark National and Preserve. In August 1992, NPS used this photography to classify upper, middle, and lower intertidal habitats of the entire 130 miles shoreline of the park. In addition to geomorphological classification, field surveys were conducted in August 1992 to measure beach profiles and inventory intertidal flora and infauna at selected transects.

During 1994-96, park staff and cooperators conducted a coastal resource inventory to obtain baseline data on coastal geomorphology, intertidal habitats, and distributions and abundance's of marine and near-coastal vertebrates and invertebrates. Intertidal shoreline habitats were classified at a minimum spatial scale of 10 m horizontally. The shoreline was partitioned into 338 upper, 246 middle, and 207 lower intertidal polygons with homogeneous morphodynamic attributes such as wave runup, substrate character, slope angle, and aspect (Schoch 1996). The attributes of each polygon were described and quantified allowing for statistical calculations for parametric or spatial distribution modeling of nearshore habitats.

Coastal resource data and metadata were compiled into a digital database and geographical information system (GIS) on CD-ROM. Data layers developed and projected for Lake Clark National Park-Cook Inlet Coastline GIS include: land status, bathymetry, topography, surface hydrology, nearshore rocks, intertidal shoreline segments, geomorphology, salt marsh vegetation, beach profile transects, invertebrate sample sites, waterbird density, raptor nests, seabird colonies, and harbor seal haulouts.

Biological Resources

Flora

There are no threatened or endangered species of plants listed by the U.S. Fish and Wildlife Service (1998) in LACL. The Alaska Natural Heritage Program Rare Vascular Plant Tracking List for April 2000 identifies 25 plant species that are classified by the State as critically imperiled (S1), imperiled (S2), or rare or

uncommon (S3). Several rare species are exclusively associated with wetland, riparian or lakeshore habitats.

Coastal side: The Cook Inlet coast has a narrow fringe with coastal salt marshes in Tuxedni and Chitintna Bays and scattered marshes and lagoons along the Inlet coast. Coastal zones without marshes have long gravel beaches or bedrock cliffs rising abruptly out of Cook Inlet. The salt marshes are a rich zone of sedges and some grasses with varying tolerance to salt water flooding, and form an early spring food source for bears grazing along the beaches. Much of the Lake Clark coast appears to be rising from tectonic movements and narrow bands of young spruce are establishing themselves into the *Elymus* grass community back of the beaches. The depositional flats and lower mountainsides behind the beaches are covered with spruce forests and alder thickets. Both white and Sitka spruce grow along the coast, with Sitka generally south of the Johnson River, and white spruce to the north. Conifer forests have multi-aged trees with thick moss understory, devil's club, salmonberry and scattered alder. Scattered stands of spruce rise out of a sea of alder, especially around the Tuxedni coast and above the dense spruce forest. Alder thickets grow above the spruce zone, thinning out into *Calamagrostis* meadows at the upper limits. The alpine tundra zone is very narrow on the coastal side of the mountains, dominated by *Luetka* and *Empetrum* and forbs. Tundra yields to bedrock and ice.

Mountainous spine: The center of the park is primarily glacial ice and bedrock or till. Most valley glaciers are in retreat, leaving large expanses of moraines and ground till, which are slowly revegetating with mosses and lichens, fireweed and Dryas, willow and alder. An ecosystem of note is the expansive shallow wetlands along the Neacola River, which runs into Chakachamna Lake. The valley provides rich habitat for beaver, moose, nesting waterfall and bear. The wetlands appear to be dominated by sedges and willows, and are maintained by flooding and beaver activity.

Lake side: The western side of the park is dominated by a series of large long lakes with their eastern extents in the Alaska Range, and their western edge bounded by terminal moraines from the most recent advances of large valley glaciers. Low ridges and subdued mountains lie between the lake systems. The northern part of the park, by the Stony River, is boreal in character, with black spruce, muskegs, aspen and birch, and wildfire. Further south, vegetation is a mosaic of spruce and mixed spruce/birch or cottonwood forests, paper birch, low shrubs dominated by dwarf birch, dwarf shrub tundra with ericaceous shrubs, scattered wetlands and alpine tundra. Vegetation patterns are arrayed in response to soil texture and drainage patterns from a complex glacial and alluvial history.

In 1996, as part of a LACL coastal inventory project, salt marshes (32 km^2) were delineated and mapped at a scale of 1:12,000 (Tande 1996). Five attributes were interpreted for each of 1,286 map polygons: Physiographic Location - 4

classes; Site Moisture - 2 classes; Vegetation Type -27 classes; Growth Form - 8 classes; and Landscape Feature - 13 classes. These attributes may be treated as independent variables or in combination for analysis of salt marsh vegetation communities.

Fauna

Marine Invertebrates

Intertidal sand flats in some locations within LACL support dense populations of mollusc bivalves, including razor, littleneck, and soft-shell clams. Intertidal mud flats in Chinitna and Tuxedni Bays support large to moderate standing crops of suspension and deposit feeding invertebrates (Lees 1977). Eighteen species of Polychaeta, 7 species of Mollusca and 12 species of Crustacea have been identified in Chinitna Bay (Bennett 1996). Infauna in both bays are dominated by the pink clam (*Macoma balthica*).

The trophic relationship between shorebirds, sea ducks, diving ducks and Macoma may be the most significant near coastal predator-prey linkage along the Lake Clark National Park-Cook Inlet Coastline (Bennett 1996). In 1996, baseline contaminant levels were established for *Macoma balthica* in Chinitna and Tuxedni Bays (Cook Inlet RCAC 1996). Contaminant analysis included polycyclinc aromatic hydrocarbons, alkyulated homologues, trace metal analysis, and bivalve condition index.

Fish

Forty-six species of fish are listed as present or probably present in LACL (Table 16). In marine waters, small pelagic schooling fish including capelin, sand lance, eulachon and Pacific herring occur in nearshore and estuarine waters, while halibut and gray cod are found offshore (Bennett, pers obs). Dominant species during summer in Tuxedni Bay include juvenile pollock, sand lance, osmerids, and herring (Piatt et al. 1999). No information exists on seasonal abundance or distribution.

Sockeye salmon are a keystone species in the Lake Clark aquatic and terrestrial ecosystem. Nutrients from spawned-out salmon carcasses play a crucial role in sustaining the productivity of riparian and lacustrine ecosystems including the perpetuation of future salmon runs (Kline et al. 1990, 1993). Sculpin, least cisco, lake trout, rainbow trout and burbot all derive nutrients from sockeye salmon in one form or another. Salmon influence the seasonal distribution and abundance of birds and mammals that prey on them. In the interior of the park and preserve, Bald Eagles are exclusively associated with river-lake systems that support salmon. Bears depend on abundant salmon to bolster fat reserves vital to survival during hibernation. Because much of Lake Clark remains ice free until February, salmon carcasses support overwintering Bald Eagles and are an important food

Table 16. Fish Species - Lake Clark (NPSpecies 2003)

Scientific Name	Common Name	Status
Order: Clupeiformes - Family: Clupeidae		
Clupea harengus pallasii	Pacific herring	Present in Park
Cypriniformes: Catostomidae		
Catostomus catostomus	longnose sucker	Present in Park
Order: Esociformes - Family: Esocidae		
Esox lucius	northern pike	Present in Park
Order: Esociformes - Family: Umbridae		
Dallia pectoralis	Alaska blackfish	Unconfirmed
Order: Gadiformes- Family: Gadidae		
Eleginus gracilis	saffron cod	Unconfirmed
Gadus macrocephalus	Pacific cod	Present in Park
Microgadus proximus	Pacific tomcod	Present in Park
Theragra chalcogramma	Alaska pollock walleye pollock	Present in Park
Order: Gadiformes- Family: Lotidae		
Lota lota	burbot	Present in Park
Order: Gasterosteiformes- Family: Gasterosteidae		
Gasterosteus aculeatus	Alaskan stickleback, threespine stickleback	Present in Park
Pungitius pungitius	ninespine stickleback, tenspined stickleback	Present in Park
Order: Osmeriformes- Family: Osmeridae		
Hypomesus olidus	pond smelt	Unconfirmed
Hypomesus pretiosus	surf smelt	Present in Park
Spirinchus thaleichthys	longfin smelt	Present in Park
Thaleichthys pacificus	eulachon	Present in Park
Order: Perciformes- Family: Ammodytidae		
Ammodytes hexapterus	Pacific sand lance	Present in Park
Order: Perciformes- Family: Stichaeidae		
Lumpenus maculatus	daubed shanny	Present in Park
Lumpenus sagitta	snake prickleback	Present in Park
Order: Perciformes- Family: Trichodontidae		
Trichodon trichodon	Pacific sandfish	Present in Park
Order: Petromyzontiformes- Family: Petromyzontidae		
Lampetra japonica	Arctic lamprey	Present in Park
Lampetra tridentata	Pacific lamprey	Probably Present
Order: Pleuronectiformes- Family: Pleuronectidae		
Atheresthes stomias	arrowtooth flounder	Present in Park
Limanda aspera		Present in Park
Platichthys stellatus	starry flounder	Present in Park
Pleuronectes isolepis	butter sole	Present in Park
Order: Salmoniformes- Family: Salmonidae		
Coregonus clupeaformis	lake whitefish	Present in Park
Coregonus pidschian	humpback whitefish	Unconfirmed
Coregonus sardinella	least cisco	Present in Park
Oncorhynchus gorbuscha	pink salmon	Present in Park
Oncorhynchus keta	chum salmon	Present in Park
Oncorhynchus kisutch	Coho salmon	Present in Park
Oncorhynchus mykiss	rainbow trout	Present in Park
Oncorhynchus nerka	red salmon, sockeye salmon	Present in Park
Oncorhynchus tshawytscha	chinook salmon	Present in Park
Prosopium coulteri	pygmy whitefish	Present in Park
Prosopium cylindraceum	round whitefish	Present in Park
Salvelinus alpinus	Arctic char	Present in Park
Salvelinus malma	dolly varden	Present in Park
Salvelinus namaycush	lake trout	Present in Park
Thymallus arcticus	Arctic grayling	Present in Park
Order: Scorpaeniformes- Family: Agonidae		
Agonus acipenserinus		Present in Park
Asterotheca alascana	gray starsnout	Probably Present
Pallasina barbata	tubenose poacher	Present in Park
Order: Scorpaeniformes- Family: Cottidae		

Clinocottus acuticeps	sharpnose sculpin	Unconfirmed
Cottus aleuticus	coastrange sculpin	Present in Park
Cottus cognatus	slimy sculpin	Present in Park
Gymnocanthus galeatus	armorhead sculpin	Present in Park
Icelinus borealis	northern sculpin	Probably Present
Leptocottus armatus	Pacific staghorn sculpin	Present in Park
Order: Scorpaeniformes- Family: Cyclopteridae		
Liparis gibbus	polka-dot snailfish, variegated snailfish	Present in Park
Order: Scorpaeniformes- Family: Hexagrammidae		
Hexagrammos octogrammus	masked greenling	Present in Park

resource for an array of vertebrate predators and scavengers including wolves, coyotes, red fox, wolverine and lynx.

The U.S. Bureau of Fisheries conducted the first fisheries surveys of Lake Clark in August 1920. They found Dolly Varden in Kijik Lake, northern pike in Chulitna River, lake trout in Lake Clark, and sockeye salmon in Lake Clark and several of its tributaries. Grayling, arctic char, rainbow trout, burbot and several species of whitefish also occur. These species are widely distributed in the major lake-river systems throughout LACL, however park waters are not considered highly productive for resident species due to low water temperatures and low nutrients (USDI 1975).

Follow-up surveys were conducted in 1921-22, 1924-28, 1931, 1933, 1937-38, 1940, and 1947-49. Accounts of these surveys were published in Reports of the Commissioner of Fisheries to the Secretary of Commerce, Alaska Fishery and Fur Seal Industries. The Alaska Department of Fish and Game conducted a fisheries resource inventory within the proposed LACL boundaries in 1978-1979. The study encompassed 27 lakes and portions of 13 rivers. Information included fish distribution, age and growth, relative abundance, food habits, and spawning area (salmon species). Limited liminological data were also collected (ADF&G and USNPS 1980).

The U.S. Bureau of Fisheries obtained numerical estimates of sockeye salmon escapement to particular spawning areas during some years of their surveys, but for other years only subjective statements describing apparent run strength appear (i.e., "not as numerous as in previous years"). In 1950 the Fisheries Research Institute (FRI) of the University of Washington began conducting salmon related investigations in the Kvichak River watershed, including the Lake Clark area (Demory et al. 1964). Their efforts were directed primarily at obtaining information on factors affecting sockeye salmon production. Their studies at Lake Clark have included bathymetric measurements (Anderson 1969), cataloging of sockeye salmon spawning areas including bottom type descriptions and total spawning area (Demory et al. 1964; Anderson 1968), determination of juvenile sockeye distribution, abundance, age, and growth (Orrell 1963; Kerns 1968) and compilation of annual indices of sockeye escapement (Demory et al. 1964; Anderson 1968; Anderson and Poe 1969). Recent studies have focused on feeding competition between sockeye salmon pre-smolts and least cisco (C. Foote, FRI, personal communications).

Since 1999, the USGS-Biological Resources Division, along with a number of cooperators, has been investigating various aspects of sockeye salmon ecology throughout the Lake Clark watershed. Studies are still ongoing and include genetic diversity, population abundance and trends, salmon movement patterns, and location and characterization of spawning sites. Preliminary results indicate that Lake Clark salmon are genetically distinct from other Kvichak River and Bristol Bay populations. Dramatic declines in salmon escapement have continued to occur since 1996, with an estimated 221,418 fish (20% of the estimated Kvichak escapement) counted in the Newhalen River in 2001. Discharge measurements for the Newhalen River demonstrated the effects of a velocity barrier to fish passage, which delayed run timing in 2001(Woody 2001).

Salmon radiotagged as they entered Lake Clark yielded new data on contemporary migration paths and spawning distributions. Lake Clark salmon show an unusually high affinity for lakeshore spawning sites (Woody, pers. comm. 2002). Remote temperature sensing units have been deployed at 14 spawning locations to monitor incubation temperature. Woody and Young are collecting data on basic habitat characteristics and determining fluvial process groups for spawning sites (Young and Woody 2001).

Long term changes in salmon abundance are being determined through lake bottom sediment core analysis. Salmon transport nutrients, including nitrogen isotopes (^{15}N), from the ocean to freshwater spawning sites. ^{15}N released after death accumulates in lake bottom sediments, which can be used to determine fluctuations in salmon abundance throughout prehistory (Woody 2002).

Terrestrial Mammals

Thirty-six species of terrestrial mammals are documented or expected to occur within Lake Clark National Park and Preserve (Table 17). Other than periodic efforts to monitor moose and Dall sheep populations (Twitchell 1985; Adams 1986; Bennett undated), a winter track study of furbearers at Telaquana Lake (Stevenson and Jeschke 2000), and more recent efforts to monitor the impact of human visitation on coastal brown bears and to estimate populations, there have been few studies of terrestrial mammals.

Moose — Moose trend surveys were conducted in 3 areas between 1984 and 1992. Stratified random sampling (Gasaway et al. 1986) yielding density and population estimates in 3 survey units were initiated in 1992. Each unit was to be surveyed on a 3 year rotational schedule, but due to factors such as poor survey conditions this goal has not been meet.

Population estimates for the survey unit south of Lake Clark were 241.3 ± 70.0 in 1992 and 229.1 ± 37.4 in 1998. bull:cow ratios decreased from 73.3 in 1992 to 36.7 in 1998. Cow:calf ratios were 12.5 and 8.3 in 1992 and 1998, respectively.

Table 17: Mammal Species – LACL (NPSpecies 2003, Bennett 1996)

Scientific Name	Common Name
Order: Artiodactyla - Family: Bovidae	
Ovis dalli	Dall sheep
Order: Artiodactyla - Family: Cervidae	
Alces alces	Moose
Rangifer tarandus	Caribou
Order: Carnivora - Family: Canidae	
Canis latrans	Coyote
Canis lupus	Wolf
Vulpes vulpes	Red fox
Order: Carnivora - Family: Felidae	
Lynx canadensis	Lynx
Order: Carnivora - Family: Mustelidae	
Enhydra lutris	Sea otter
Gulo gulo	Wolverine
Lutra canadensis	River otter
Martes americana	Marten
Mustela erminea	Ermine
Mustela nivalis	Least weasel
Mustela vison	Mink
Order: Carnivora – Family: Phocidae	
Phoca vitulina	Harbor seal
Order: Carnivora - Family: Ursidae	
Ursus americanus	Black bear
Ursus arctos	Brown bear
Order: Cetacea – Family: Monodontidae	
Delphinapterus leucas	**beluga whale**
Order: Chiroptera - Family: Vespertilionidae	
Myotis lucifugus	Little brown bat
Order: Insectivora - Family: Soricidae	
Sorex arcticus	Arctic shrew
Sorex cinereus	Masked shrew
Sorex hoyi	Pygmy shrew
Sorex monticolus	Dusky shrew
Sorex palustris	Northern water shrew
Order: Lagomorpha - Family: Leporidae	
Lepus americanus	Snowshoe hare
Order: Lagomorpha - Family: Ochotonidae	
Ochotona collaris	Collared pika
Order: Rodentia - Family: Castoridae	
Castor canadensis	Beaver
Order: Rodentia - Family: Dipodidae	
Zapus hudsonius	Meadow jumping mouse
Order: Rodentia - Family: Erethizontidae	
Erethizon dorsatum	Porcupine
Order: Rodentia - Family: Muridae	
Clethrionomys rutilus	Northern red-backed vole
Dicrostonyx groenlandicus	Collared lemming
Lemmus trimucronatus	Brown lemming
Microtus miurus	Singing vole
Microtus oeconomus	Tundra vole
Microtus pennsylvanicus	Meadow vole
Ondatra zibethicus	Muskrat
Synaptomys borealis	Northern bog lemming
Order: Rodentia - Family: Sciuridae	
Marmota caligata	Hoary marmot
Spermophilus parryii	Arctic ground squirrel
Tamiasciurus hudsonicus	Red squirrel

Population estimates for the 2 survey units north of Lake Clark were 342.5 ± 70.9 and 596.6 ± 61.8 in 1994 and 1999, respectively. A moose sightability study using radiocollared animals will be completed in 2003, and a sightability model will be developed and used to obtain more reliable moose survey data. A project to determine moose seasonal ranges, adult survival, and calf productivity and survival in areas where subsistence harvest is concentrated was conducted from 1996-2000. Results of this study along with population surveys indicate low calf production and/or survival. A 3 year moose forage availability and use study will begin in 2003.

Dall sheep — Dall sheep reach the southern extent of their range in LACL and occur along the western slopes of the Chigmit Mountains on the common boundary of the park and preserve. Eight Dall sheep aerial surveys have been conducted from 1978-1995. Complete surveys, encompassing 6 units, were conducted in 1981 and 1987 resulting in a total count of 805 and 1088 sheep,

respectively. Stratified random sampling of subunits within the 6 survey units resulted in population estimates of 520 and 716 sheep in 1992 and 1995. Ewe:lamb ratios declined from 58.0 and 76.6 during the 1981 and 1987 surveys to estimates of 37.5 and 31.8 in 1992 and 1995. New Dall sheep projects will begin in 2003. Aerial surveys will be conducted in survey units 1 and 2 in response to proposals from the Lake Clark Subsistence Resource Commission to liberalize subsistence sheep harvest regulations. Aerial surveys and intensive monitoring of a sheep mineral lick will be conducted in the Twin Lakes area of the park.

Caribou — The Mulchatna Caribou Herd (MCH) calves adjacent to the western boundary of the preserve and ranges through the foothill lakes and tundra plains of the western preserve. This herd is one of the most important for local subsistence and non-local Alaska hunters and heavily supports Alaska's guide and transporter industry. Recent Alaska Department of Fish and Game (ADF&G) data suggests the herd is slowly declining from a high of over 200,000 to its current estimated size of 147,000. Bull:cow ratios are declining as well.

Bears — Brown/grizzly bears, common in all habitats, are most numerous along the coast, where an estimated 180-230 bears graze in salt marshes during the summer (Bennett 1996). An intensive and systematic effort was made to collect data on brown bear use of coastal salt marshes in Tuxedni Bay during 2001 and in Chinitna Bay during 2001-02. Data are currently being analyzed. Monitoring at Tuxedni Bay revealed numerous low level aircraft passes over bears and several boat trips, presumably related to bear viewing tourist activities.

Bear viewing is well established at Chinitna Bay. Since 1996, a guide service located on private land adjacent to bear foraging areas has offered overnight lodging and day trips. Other guiding services are considering purchases of nearby private inholdings for the purpose of offering bear viewing opportunities to clients.

Efforts to derive black and brown bear density and population estimates over large areas of the park and preserve are being conducted in cooperation with ADF&G. A significant portion of Game Management Unit (GMU) 9B, centered on Lake Clark was surveyed using an aerial line transect double count technique in 1999 and 2000. Preliminary analysis indicates a density of 40.9 brown bears per thousand square kilometers. This aerial census technique will be used to determine bear density and population parameters in GMU 9A, which includes the park's coastal habitat, in 2003. Black bears (Ursus americanus) use all areas of the park and preserve except the higher elevations. Data for black bears is not yet available from the GMU 9B survey.

Other terrestrial mammals - Wolves, lynx, coyotes, and wolverines range widely throughout the forests and low alpine areas, also populated with porcupines and snowshoe hares. Hoary marmots, arctic ground squirrels, and pikas occur in alpine meadows and boulder fields. Twelve species of vole, lemming and shrew

probably occur, of which the redback vole is most abundant. Mink, beaver and river otter inhabit ponds, lakes and rivers. River otters are particularly common along the coast. Red squirrel, American marten, shorttail weasel and least weasel are also found throughout the park and preserve. Little is known about the abundance and distribution of these species in LACL.

Marine Mammals

Harbor seals (200-250 animals) haul out at 3 sites (Tuxedni Bay, Chinitna Bay and Johnson River) and pup near the mouth of the Tuxedni River (Bennett 1996). Beluga whales seasonally occur off the mouths of glacial rivers in both bays and are most numerous (160-200 animals) during August and September (Bennett 1996, Speckman and Piatt 2000). Sea otter occasionally stray into park waters but are more common in the clearer waters south of the park (Bennett 1996).

Birds

One hundred eighty-nine species of birds are documented or expected to occur in the park and preserve (Table 18). Of these, 70 are landbirds, and many are neotropical migrants. Raptors, including Bald Eagle, Golden Eagle, Northern Goshawk, Sharp-shinned Hawk, Northern Harrier , and Merlin, breed in the area. About 50 pairs of Bald Eagles and 5-10 pairs of Golden Eagles are known to nest in the park and preserve. Two pairs of Osprey also nest in the preserve. Bald Eagle nest occupancy and productivity has been monitored yearly throughout the park and preserve since 1992. Peregrine Falcons occupy eyries on cliffs along interior lakes and rivers, and at Tuxedni Bay (Haugh and Potter 1975, Bennett 1996). Peregrine Falcon eyries and breeding activity were observed at 6 sites along the park coastline from 1994-96 (Bennett 1996).

Little is know regarding abundance and distribution of other land birds, including neotropical migrants, in Lake Clark National Park and Preserve. The breeding biology of the montane nesting Surfbird was studied in a 100 km² area centered at Turquoise Lake from 1997-98 (Gill et. al. 1999). Data on nesting Wandering Tattlers as well as opportunistic sightings of birds and mammals was also obtained during this study.

Waterfowl nest and molt in wetlands throughout the area. Large migratory flocks of ducks, swans, and geese rest and feed in the park and preserve before flying from Nikabuna Lakes to Lake Clark through low mountain passes in the Chulitna River drainage. Bennett (1996) determined migratory waterfowl numbers and distribution, and productivity of local breeding species, trumpeter swans and common loons along the coast from 1994-1996.

Sea ducks, primarily White-winged Scoters and Surf Scoters, are the most abundant waterfowl on the coast, numbering over 18,000 in mid-August. The coast also provides important breeding habitat for Mallards, American Widgeon,

Table 18: Bird Species – LACL (NPSpecies 2003)

Scientific Name	Common Name
Order: Anseriformes - Family: Anatidae	
Anas acuta	Northern pintail
Anas americana	American wigeon
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas penelope	Eurasian wigeon
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anser albifrons	White-fronted goose
Aythya affinis	Lesser scaup
Aythya americana	Redhead
Aythya collaris	Ring-necked duck
Aythya marila	Greater scaup
Aythya valisineria	Canvasback
Branta bernicla	Brant
Branta canadensis	Canada goose
Bucephala albeola	Bufflehead
Bucephala clangula	Barrow's goldeneye
Bucephala islandica	Common goldeneye
Chen caerulescens	Snow goose
Chen canagica	Emperor goose
Clangula hyemalis	Long-tailed Duck
Cygnus buccinator	Trumpeter swan
Cygnus columbianus	Tundra swan
Histrionicus histrionicus	Harlequin duck
Anas americana	American wigeon
Melanitta fusca	White-winged scoter
Melanitta nigra	Black scoter
Melanitta perspicillata	Surf scoter
Mergus merganser	Common merganser
Mergus serrator	Red-breasted merganser
Cygnus columbianus	Tundra swan
Somateria mollissima	Common eider
Order: Ciconiiformes - Family: Accipitridae	
Accipiter gentilis	Northern goshawk
Accipiter striatus	Sharp-shinned hawk
Aquila chrysaetos	Golden eagle
Buteo jamaicensis	Red-tailed hawk
Buteo lagopus	Rough-legged hawk
Circus cyaneus	Northern harrier
Haliaeetus leucocephalus	Bald eagle
Pandion haliaetus	Osprey
Order: Ciconiiformes - Family: Ardeidae	
Ardea herodias	Great blue heron
Order: Ciconiiformes - Family: Charadriidae	
Charadrius semipalmatus	Semipalmated plover
Haematopus bachmani	Black oystercatcher
Pluvialis dominica	American golden-plover
Pluvialis fulva	Pacific golden-plover
Pluvialis squatarola	Black-bellied plover
Order: Ciconiiformes - Family: Falconidae	
Falco columbarius	Merlin
Falco peregrinus	Peregrin falcon
Falco rusticolus	Gyrfalcon
Falco sparverius	American kestrel
Order: Ciconiiformes - Family: Gaviidae	
Gavia immer	Common loon
Gavia pacifica	Pacific loon
Gavia stellata	Red-throated loon
Order: Ciconiiformes - Family: Laridae	
Aethia psittacula	Parakeet auklet
Brachyramphus brevirostris	Kittlitz's murrelet
Brachyramphus marmoratus	Marbled murrelet
Cepphus columba	Pigeon guillemot
Cerorhinca monocerata	Rhinoceros auklet
Fratercula cirrhata	Tufted puffin
Fratercula corniculata	Horned puffin
Larus argentatus	Herring gull
Larus atricilla	Franklin's gull
Larus canus	Mew gull
Larus glaucescens	Glaucous-winged gull
Larus hyperboreus	Glaucous gull
Larus philadelphia	Bonaparte's gull
Larus pipixcan	Franklin's gull
Fratercula cirrhata	Tufted puffin
Rissa tridactyla	Black-legged kittiwake
Stercorarius longicaudus	Long-tailed jaeger
Stercorarius parasiticus	Parasitic jaeger
Stercorarius pomarinus	Pomarine jaeger
Sterna aleutica	Aleutian tern
Sterna paradisaea	Arctic tern
Uria aalge	Common murre
Order: Ciconiiformes - Family: Phalacrocoracidae	
Phalacrocorax auritus	Double-crested cormorant
Phalacrocorax pelagicus	Pelagic cormorant
Order: Ciconiiformes - Family: Podicipedidae	
Podiceps auritus	Horned grebe
Podiceps grisegena	Red-necked grebe
Order: Ciconiiformes - Family: Procellariidae	
Oceanodroma furcata	Fork-tailed storm-petrel
Order: Ciconiiformes - Family: Scolopacidae	
Actitis macularia	Spotted sandpiper

Aphriza virgata	Surfbird
Arenaria interpres	Ruddy turnstone
Arenaria melanocephala	Black turnstone
Calidris alba	Sanderling
Calidris alpina	Dunlin
Calidris bairdii	Baird's sandpiper
Calidris canutus	Red knot
Calidris mauri	Western sandpiper
Calidris melanotos	Pectoral sandpiper
Calidris minutilla	Least sandpiper
Calidris ptilocnemis	Rock sandpiper
Calidris pusilla	Semipalmated sandpiper
Gallinago gallinago	Common snipe
Heteroscelus incanus	Wandering tattler
Limnodromus griseus	Short-billed dowitcher
Limnodromus scolopaceus	Long-billed dowitcher
Limosa haemastica	Hudsonian godwit
Numenius phaeopus	Whimbrel
Phalaropus fulicarius	Red phalarope
Phalaropus lobatus	Red-necked phalarope
Tringa flavipes	Lesser yellowlegs
Tringa melanoleuca	Greater yellowlegs
Tringa solitaria	Solitary sandpiper
Order: Coraciiformes - Family: Cerylidae	
Ceryle alcyon	Belted kingfisher
Order: Galliformes - Family: Phasianidae	
Bonasa umbellus	Ruffed grouse
Dendragapus canadensis	Spruce grouse
Lagopus lagopus	Willow ptarmigan
Lagopus leucurus	White-tailed ptarmigan
Lagopus mutus	Rock ptarmigan
Order: Gruiformes - Family: Gruidae	
Grus canadensis	Sandhill crane
Order: Gruiformes - Family: Rallidae	
Fulica americana	American coot
Order: Passeriformes - Family: Alaudidae	
Eremophila alpestris	Horned lark
Order: Passeriformes - Family: Bombycillidae	
Bombycilla garrulus	Bohemian wagwing
Order: Passeriformes - Family: Certhiidae	
Certhia americana	
Certhia familiaris	
Order: Passeriformes - Family: Cinclidae	
Cinclus mexicanus	American dipper
Order: Passeriformes - Family: Corvidae	
Corvus caurinus	Northwestern crow
Corvus corax	Common raven
Cyanocitta stelleri	Steller's jay
Perisoreus canadensis	Gray jay
Pica pica	Black-billed magpie

Order: Passeriformes - Family: Fringillidae	
Calcarius lapponicus	Lapland longspur
Carduelis flammea	Common redpoll
Carduelis hornemanni	Hoary redpoll
Carduelis pinus	Pine siskin
Dendroica coronata	Yellow-rumped warbler
Dendroica petechia	Yellow warbler
Dendroica striata	Blackpoll warbler
Euphagus carolinus	Rusty blackbird
Junco hyemalis	Dark-eyed junco
Leucosticte tephrocotis	Gray-crowned Rosy-finch
Loxia curvirostra	Red crossbill
Loxia leucoptera	White-winged crossbill
Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow
Passerculus sandwichensis	Savannah sparrow
Passerella iliaca	Fox sparrow
Pinicola enucleator	Pine grosbeak
Plectrophenax nivalis	Snow bunting
Seiurus noveboracensis	Northern waterthrush
Spizella arborea	American tree sparrow
Vermivora celata	Orange-crowned warbler
Wilsonia pusilla	Wilson's warbler
Zonotrichia atricapilla	Golden-crowned sparrow
Zonotrichia leucophrys	White-crowned sparrow
Order: Passeriformes - Family: Hirundinidae	
Hirundo pyrrhonota	Cliff swallow
Riparia riparia	Bank swallow
Tachycineta bicolor	Tree swallow
Tachycineta thalassina	Violet-green swallow
Order: Passeriformes - Family: Laniidae	
Lanius excubitor	Northern shrike
Order: Passeriformes - Family: Muscicapidae	
Catharus guttatus	Hermit thrush
Catharus minimus	Gray-cheeked thrush
Catharus ustulatus	Swainson's thrush
Myadestes townsendi	Townsend's solitaire
Oenanthe oenanthe	Northern wheatear
Turdus migratorius	American robin
Order: Passeriformes - Family: Paridae	
Parus atricapillus	Black-capped chickadee
Parus hudsonicus	Boreal chickadee
Order: Passeriformes - Family: Passeridae	
Anthus rubescens	American pipit
Motacilla flava	Yellow wagtail
Order: Passeriformes - Family: Regulidae	
Regulus calendula	Ruby-crowned kinglet
Regulus satrapa	Golden-crowned kinglet
Order: Passeriformes - Family: Sittidae	
Sitta canadensis	Red-breasted nuthatch

Order: Passeriformes - Family: Sylviidae	
Phylloscopus borealis	Arctic warbler
Order: Passeriformes - Family: Turdidae	
Ixoreus naevius	Varied thrush
Order: Passeriformes - Family: Tyrannidae	
Empidonax alnorum	Alder flycatcher
Sayornis saya	Say's phoebe
Order: Piciformes - Family: Picidae	
Picoides pubescens	Downy woodpecker
Picoides tridactylus	Three-toed woodpecker
Picoides villosus	Hairy woodpecker
Order: Strigiformes - Family: Strigidae	
Aegolius acadicus	Northern saw-whet owl
Aegolius funereus	Boreal owl
Asio flammeus	Short-eared owl
Bubo virginianus	Great horned owl
Strix nebulosa	Great gray owl
Surnia ulula	Northern hawk-owl
Order: Trochiliformes - Family: Trochilidae	
Selasphorus rufus	Rufous hummingbird

Barrow's Golden-eye, and Red-throated Loons. Migrating dabbling ducks number 3,000-4,000 in spring and fall. Diving ducks, primarily Greater and Lesser Scaup, stage along the coast in spring. They reach peak abundance (16,400 birds) in mid-May. Other ducks include Green-winged Teal, Northern Pintail, Harlequin, Common Golden-eye, Black Scoter, Common Eider, Bufflehead, and Long-tailed Duck. About 30 pairs of Trumpeter Swans nest in the park and preserve; most breed in wetlands on the coast. Canada geese occur in Tuxedni Bay and can number about 4,400 during fall migration.

Seabird breeding colonies occur along Cook Inlet, and concentrate at Tuxedni and Chinitna Bays (Bennett 1996). Of the seven seabird colonies surveyed from 1994 to 1996, the largest contained 2,700 Black-legged Kittiwakes. Less numerous seabirds include Horned Puffins, Double-crested Cormorants, Pelagic Cormorants, Glaucous-winged Gulls, Tufted Puffins, Common Murres, and Pigeon Guillemots.

During spring migration, 86,000 to 122,000 shorebirds, primarily Western Sandpipers and Dunlin, use intertidal mud flats in Tuxedni and Chinitna Bays (Bennett 1996). The Alaska Shorebird Working Group has identified Cook Inlet as critical for supporting hemispherically significant populations of Whimbrel, Hudsonian Godwit, Rock Sandpiper and Western Sandpiper. Rock Sandpipers, designated as a "Species of High Concern", winter in Tuxedni Bay. Tuxedni Bay qualifies as an International Reserve in the Western Hemisphere Shorebird Reserve Network (Andres & Gill 2000).

Threatened and Endangered Species

Currently no federally listed species are known to occur in terrestrial areas of LACL. Federal species of concern (formerly category 2 candidate species) that occur in terrestrial areas of LACL include the Harlequin Duck, Olive-sided Flycatcher, and lynx. The American Peregrine Falcon was delisted in 1999, but will be listed by the USFWS as a species of concern for five years.

American Peregrine Falcon, Olive-sided Flycatcher, Gray-cheeked Thrush, Townsend's Warbler, and Blackpoll Warbler are State of Alaska Species of Special Concern that have been documented or are expected to occur in LACL.

Natural Resources Management Issues

- **Air Quality-** Quantitative air quality data are limited throughout Alaska and currently no baseline air quality data exist for LACL (USNPS 1999c). The park includes environments extremely susceptible to contaminants because of poor buffering geology. Numerous sources for airborne contamination exist in the Lake Clark region including emissions from offshore oil/gas development in Cook Inlet and coal extraction at the Beluga coal fields northeast of the park

- **Climate Change.** LACL's environment is thought to be very susceptible to climate change. In 1938, a glacial toe five miles wide filled Lake Clark Pass (Alaska Geographic Society 1986). Today the glaciers in Lark Clark Pass have receded into the higher mountain valleys, suggesting that the climate has warmed.

- **Mining-** Under the Alaska Native Claims Settlement Act of 1976 (ANCSA), the Cook Inlet Region Corporation (CIRI) received title to approximately 21,000 acres of land known as the "Johnson River Tract" located on the west side of Cook Inlet in LACL. Based on the current size estimate of the ore body, approximately 270,000 tons of ore would be mined and transported annually over a 3-year mine life (USNPS 1999c; CIRI and WestMin 1994). Due to the proximity of the planned mine and support network of roads and ore stockpiles to the Johnson River, there is a high potential for contaminants to reach the Johnson River estuary and be transported along the coastline by prevailing tidal currents (Bennett 1996).

- **Logging-** The Circle DE Pacific Corporation received approval to conduct timber harvesting activities on approximately 2,403 acres of beetle killed timber along LACL's coast in Tuxedni Bay within the Crescent River watershed. Approximately three miles of primary roads and six miles of secondary roads were built in 1998, and additional road construction, as well as a bridge across the Crescent River, is planned.

- **Hydroelectric Development-** The Iliamna-Newhalen-Nondalton Electric Corporation operates a 700 kW facility at Tazimina River mile 9.5 within the park boundary but on lands owned by the Iliamna Natives Limited and the Bristol Bay Corporation (HDR Engineering, Inc. 1992). The hydroelectric design uses natural "run-of-the-river" flows to power the turbines, which should create no noticeable effects in the Tazimina River flow regime, except between the intake and tailrace

- **Petroleum development, storage, and transportation-** Presently, both the state and federal governments are planning to sell oil and gas leases near the Lake Clark coast, with federal lease sales for the lower Cook Inlet scheduled

for 2004 and 2006, and state sales for coastal and uplands areas scheduled for 2004, 2005, and 2006.

The strong currents and high tidal ranges along the Alaskan coast can transport oil spills great distances from their source, as evidenced by the *Exxon Valdez* oil spill of March 24, 1989. Numerous petroleum facilities occur along the north gulf coast. The Valdez terminal in Prince William Sound receives approximately 24 billion gallons of oil per year via the TransAlaska Pipeline. There are also 15 production platforms operating in Cook Inlet. The Drift River Marine Terminal is a privately owned offshore oil loading platform in Cook Inlet with an onshore storage facility. The Nikiski oil terminal and refinery is located on the Eastern Shore of Cook Inlet. These two oil-loading facilities transfer over 3.3 billion gallons of oil per year (Potts et al., 1993).

- **Residential Development-** Residential subdivision and economic development on private lands within LACL's boundary can conflict with the park's enabling legislation and NPS management objectives. About 617,000 acres are in private or state ownership, or are being adjudicated. This includes approximately 75% of Lake Clark's shoreline and more than 90% of the park coastline along Cook Inlet (USNPS 1999c).

- **Commercial Fishing-** The number of adult salmon returning to this watershed has declined in recent years and in 1996 was 75% below the previous 10-year average. Commercial fishing of mixed stocks of sockeye salmon, such as occurs in the Bristol Bay Naknek-Kvichak Commercial Fishing District has the potential to overharvest or eliminate small populations (Willson and Halupka 1995). Due to the mix of glacial and clear-water aquatic habitats within this vast system, genetic differentiation is likely (Wood 1995).

- **Sport and Subsistence Fishing-** The NPS estimates that about 1,600 sport hunting days, 3,500 angler days, and 30 to 35 river trips occur in LACL annually (National Park Service 1999d), and this number is increasing. In addition, the number of subsistence fishing permits issued for this system has tripled during the past 10 years. This increase in visitor and subsistence use has also increased resource impacts.

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